MONTHLY WEATHER REVIEW.

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The MONTHLY WEATHER REVIEW summarizes the current manuscript data received from about 3,500 land stations in the United States and about 1,250 ocean vessels; it also gives the general results of the study of daily weather maps based on telegrams or cablegrams from about 200 North American and 40 European, Asiatic, and oceanic stations.

The hearty interest shown by all observers and correspondents is gratefully recognized.

Acknowledgment is also made of the specific cooperation of the following chiefs of independent, local, or governmental services: R. F. Stupart, Esq., Director of the Meteorological Service of the Dominion of Canada; Señor Manuel E. Pastrana, Director of the Central Meteorological and Magnetic Observatory of Mexico; Señor Camilo A. Gonzales, Director-General of Mexican Telegraphs; Capt. S. I. Kimball, General Superintendent of the United States Life-Saving Service; Commandant Francisco S. Chaves, Director of the Meteorological Service of the Azores, Ponta Delgada, St. Michaels, Azores; Dr. W. N. Shaw, Director of the Meteorological Office, London; Maxwell Hall, Esq., Government Meteorologist, Kingston, Jamaica; Rev. L. Gangoiti, Director of the Meteorological Observatory of Belen College, Havana, Cuba; Señor Luis G. y Carbonell, Director, Meteorological Service of Cuba, Havana, Cuba; Rev. José Algué, S. J., Director of the Phillipine Weather Bureau, Manila; Maj. Gen. M. A. Rykachef, Director of the Physical Central Observatory, St. Petersburg, Russia; Carl Ryder, Director, Danish Meteorological Institute, Copenhagen, Denmark.

As far as practicable the time of the seventy-fifth meridian is used in the text of the MONTHLY WEATHER REVIEW.

Barometric pressures, both at land stations and on ocean vessels, whether station pressures or sea-level pressures, are reduced, or assumed to be reduced, to standard gravity, as well as corrected for all instrumental peculiarities, so that they express pressure in the standard international system of measures, namely, by the height of an equivalent column of mercury at 32° Fahrenheit, under the standard force, i. e., apparent gravity at sea-level and latitude 45°.

FORECASTS AND WARNINGS.

By Prof. E. B. GARRIOTT, in charge of Forecast Division.

From the Plains States to the Atlantic coast January was unusually dry until the closing days of the month. In the Rocky Mountain districts snowfalls were exceptionally heavy. West of the Rockies there was an excess of precipitation that over western Oregon and a greater portion of California amounted to 5 to 15 inches.

The first decade of January was very cold from the Great Lakes westward to the Pacific, and from the upper Missouri Valley westward the average temperature for this period was 15° to 25° below the seasonal average, with absolute minimum readings 30° to 55° below zero in Montana. From North Dakota to Washington and in northern Oregon the cold exceeded any previous record for the same period.

The following are among many comments that were made by the press regarding warnings issued in connection with a severe cold wave that swept the country from the Rocky Mountains to the Atlantic during the first decade of the month:

Kansas Farmers' Star, Wichita, Kans., January 8, 1909.

The weather man gave the farmers of the Southwest plenty of warning. There can't be any very good excuse for not having provided shelter for their live stock.

Market Growers' Journal, Louisville, Ky., January 16, 1909.

* * * This cold wave was forecast in a special bulletin sent out by the Weather Bureau Saturday afternoon, January 2. This forecast indicated the coldest weather of the season for States east of the Mississippi River and was issued in ample time to warn all growers who needed the warning. * * *

Post-Express, Rochester, N. Y. [illegible]

* * * Hundreds of shippers are holding [illegible] shipments on warnings from the Weather Bureau and many shipments were rushed following the warning sent out last week. The absolute accuracy of the two special forecasts made by the Weather Bureau at Washington has aroused much favorable comment among business men here and in some instances have saved thousands of dollars for nurserymen and brewers.

Daily Times-Union, Jacksonville, Fla., January 11, 1909.

* * * The point of interest involved in the forecast is the fact that nine days ago the Washington office announced the existence of conditions that favored cold wave formation, and on Monday and Tuesday the same office gave notice that the cold wave actually existed in the Northwest, and that the extreme cold would reach the seaboard States during the last of the week, which was exactly the case, for on Friday the temperature in the middle Atlantic section was about 15° above zero, and freezing prevailed over the south Atlantic section.

The merit of such long range weather predictions lies in the fact that they enable shippers to meet contingencies; for instance, the Florida shipper of fish knows that no re-icing will be necessary, and the banana shipper from Mobile and New Orleans provides the necessary warmth for his cars. Other commodities to interior points are given the necessary attention.

During the second and a great portion of the third decade of the month the weather was unusually mild generally over the United States, and from the 23d to 25th maximum readings equaled the record at numerous points from the middle and southern Rocky Mountain slope to the Atlantic coast. During the last few days of the month a storm moved eastward from the middle Rocky Mountain region to New England attended from the lower Missouri Valley eastward by the severest weather of the present season, and followed by a cold wave that carried the line of freezing temperature as far south as the middle Florida Peninsula.

The Times, Tampa, Fla., of February 1, 1909, refers editorially as follows to warnings issued in connection with this cold wave:

The Weather Bureau gave ample warning so that persons who desired and were prepared could "fire" their groves and shelter their seed beds and avoid any loss whatever. The value of the Bureau is made more evident every year by the saving it enables people to make in defending themselves against cold and storms.

BOSTON FORECAST DISTRICT.*

[New England.]

Temperature was near or slightly above normal and over the greater portion of the district precipitation was somewhat in excess of the normal, with average snowfall in northern and a deficiency of snowfall in southern portions. The only severe storm of the month occurred on the 29-30th, when severe gales swept the coast. There were no storms without warnings. Cold-wave warnings were issued on the 6th and 15th.—*J. W. Smith, District Forecaster.*

NEW ORLEANS FORECAST DISTRICT.*

[Louisiana, Texas, Oklahoma, and Arkansas.]

Temperature was above normal and precipitation was deficient thruout the district. Storm warnings issued on two dates were justified and no general storm occurred without warnings. Cold waves occurred in some parts of the district from the 5th to 7th, 9th to 12th, and on the 29th and 30th, for which warnings were issued for portions of the district, and warnings for all frosts and freezing temperatures that occurred in the sugar and trucking regions were issued.—*I. M. Cline, District Forecaster.*

LOUISVILLE FORECAST DISTRICT.*

[Kentucky and Tennessee.]

Temperature averaged above and precipitation was below normal. From the 20th to 28th temperature was remarkably high, while the last two days were quite cold with minimum temperatures about zero, and high winds and snow. Cold-wave warnings were issued on the 4th, 5th, 6th, 10th, and 29th in advance of decided changes to colder.—*F. J. Walz, District Forecaster.*

CHICAGO FORECAST DISTRICT.*

[Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas, and Montana.]

The severest cold wave of the present season advanced over the district from the 4th to 6th with temperature 20° to 30° below zero in the northwestern States and zero temperature as far south as southern Kansas and a minimum of 9° below zero at Chicago. This was the lowest temperature recorded at Chicago in nearly four years. Timely warning was given to all sections of the approach of the cold wave. The second cold wave of the month crost the district from the 10th to 12th. This cold wave had covered the northwestern States for several days and warning of its advance over the eastern portion of the district was given. A disturbance that crost the district on the 13th and 14th was followed by a cold wave in the more northern States. In this instance warnings were issued somewhat beyond the southern limits of the cold wave. Following a disturbance that moved eastward over British America during the 15th and 16th there was a period of mild temperature that culminated on the 23d with a maximum of 65° at Chicago, this being the highest January temperature recorded at that station since 1876. The weather continued mild and fair until the 28th when a storm advanced from Kansas eastward over the district attended by general precipitation, gales, and a decided fall in temperature. In connection with this storm warnings of gales were sent to open ports on Lake Michigan, heavy snow warnings to lower Michigan, forecasts of decidedly colder weather to northwestern States, and cold-wave warnings for southern and eastern portions of the district.—*E. B. Garriott, Professor and District Forecaster.*

DENVER FORECAST DISTRICT.*

[Wyoming, Colorado, Utah, New Mexico, and Arizona.]

Except in northeastern Wyoming, temperature was much in excess of the normal. At intervals heavy precipitation occurred in the Plateau and Rocky Mountain districts, and in the Rocky Mountain districts snowfall was the heaviest in January since 1895. A storm that occurred on the 28th was notably severe and was accompanied by high wind that drifted the snow and interfered seriously with mountain railroads. The cold waves of the month were erratic in movement and were accurately forecast.—*F. H. Brandenburg, District Forecaster.*

In a letter to the district forecaster at Denver dated February 3, 1909, Mr. Howard Gamble, of Sheridan Lake, Colo., states that three persons at that place owe their lives to the prompt and reliable cold-wave warnings issued by the Weather Bureau during the present winter.

SAN FRANCISCO FORECAST DISTRICT.†

[California and Nevada.]

The month as a whole was one of the stormiest experienced on this coast in many years. The rainfall was unusually heavy and continued thruout a longer period of time than any of which there is a record since January, 1849. At San Francisco, in a record covering sixty years, the total rainfall has exceeded that of the present month but three times—in 1862, 1866, and 1878. In the number of rainy days, however, the present year breaks all records, as there were 26, the average number of rainy days in January being 11. In the first decade of the month heavy rains in the valleys and melting snow in the mountains caused floods, and on the 11th killing frost occurred. Following this date storms continued practically until the end of the month, causing floods and washouts, and near the close of the month railroad communication in almost every part of the State was seriously interrupted. Storm-warnings were ordered on 19 dates.—*Alexander G. McAdie, Professor of Meteorology.*

PORTLAND, OREG., FORECAST DISTRICT.†

[Oregon, Washington, and Idaho.]

The weather was unusually stormy. Cold north to east winds continued with scarcely any interruption from the 4th to 15th, attended by heavy snow as far west as the coast line. Rivers froze that had not been frozen for many years, and the cold was intense from British Columbia to the sea. The break in the cold spell was followed by a succession of low-pressure areas that were attended by heavy rains, high winds, and mild temperatures that resulted in a breaking up of ice in the rivers. The smaller streams became bank full and the lower portion of the Willamette River was above flood stage for several days. Storm-warnings were ordered for all important storms of the month.—*E. A. Beals, District Forecaster.*

RIVERS AND FLOODS.

There were no great floods during the month except in California, and as these continued with a brief intermission, until after the end of the month their description will be delayed until the February issue of the MONTHLY WEATHER REVIEW.

Owing to the warm weather, the ice in the Hudson River at Troy and Albany, N. Y., moved out late in the afternoon of the 25th, and by the morning of the 26th there was a considerable rise in the river to within about 2 feet of the flood stages. Warning of the probable breaking of the ice and the high water was issued on the morning of the 25th.

The same general conditions prevailed in the upper watershed of the North Branch of the Susquehanna River, and the ice moved out on the morning of the 25th. Warning of the coming warm weather and rains, with consequent high water, was issued on the 21st and again on the 22d and 23d, and on the morning of the 25th the river at Binghamton, N. Y., reached a stage of 10.8 feet, 3.2 feet below the flood stage. The damage amounted to between $3,000 and $4,000, and was confined principally to the loss of a portion of the first ice crop.

Nothing of interest occurred along the other rivers, except that the rains of the 5th and 6th over the upper Ohio watershed caused a barge stage at Pittsburg, permitting the coal fleet to start southward with about 15,000,000 bushels of coal that had been awaiting this opportunity for several months.

Navigation at St. Louis, Mo., was suspended on the 1st on account of low water.

The use of the new river gage at Knoxville, Tenn., began on January 1, 1909. The zero of this gage is set at the same elevation as that of the old gage, but owing to differences in the channel at the old and new locations, the readings above the zero mark do not agree exactly, and at a stage of 16 feet on the new gage the reading on the old gage will be 17.7 feet. It is not thought that the difference (1.7 feet) will be much greater above the 16-foot mark and comparative readings will be made as soon as the first high water arrives.

* Morning forecasts made at district center, night forecasts made at Washington, D. C.

† Morning and night forecasts made at district center.

ICE.

The Missouri River at Omaha, Nebr., closed for the second time on the 8th, and at St. Joseph, Mo., on the 7th. It remained closed at Omaha at the end of the month, with ice about 8 inches in thickness, but opened on the 22d at St. Joseph. The river was also closed at Kansas City, Mo., from the 9th to the 16th, inclusive, and at Boonville, Mo., from the 11th to the 21st, inclusive.

The Mississippi River was frozen as far down as Hannibal, Mo., on the 8th, opening at Hannibal on the 23d, when the gorge above the Wabash Bridge broke. A gorge also existed above the Eads Bridge at St. Louis from the 13th to the 16th, inclusive. No ice of consequence was observed below the mouth of the Ohio River.

There was a decided increase during the month in the thickness of the ice in the Missouri and upper Mississippi rivers and in the Red River of the North, the increase amounting to more than 100 per cent. At the end of the month there was somewhat more ice than at the end of January, 1908.

There was also considerable ice in the Columbia River during the first half of the month, and at times the river was closed almost to the mouth of the Willamette River.

In the MONTHLY WEATHER REVIEW for December, 1908, mention was made of the floods of that month in the rivers of Arizona, and the following brief report thereon was made by Mr. L. N. Jesunofsky, official in charge of the local office of the Weather Bureau at Phoenix, Ariz.

Heavy precipitation occurred generally over the northern and central sections of the Territory on December 15, 16, and 17, 1908, resulting in a rapid run-off in the Verde, upper Salt, and Little Colorado rivers. The precipitation over their drainage areas averaged about 1.85 inches during the three days mentioned. During the twenty-four hours ending with 8 a. m., December 16, the Salt River at Tempe, Ariz., had risen 6 feet and was still rising rapidly. The Gila River rose slightly. At 8 a. m., December 17, the gage at Tempe read 11.5 feet, and the river was then falling after reaching a crest stage of 12 feet at 5:30 a. m. of that date. The crest past Roosevelt, on the upper Salt River, at 1:30 a. m., and over the lower Verde River at about 2:30 a. m., December 17. During this entire period the Gila River rose only 2 feet.

On the 16th warnings were sent out by telegraph that a flood stage of 12 feet would be reached by midnight of the same date, and the crest of exactly 12 feet past at 5:30 a. m., December 17. By 8 a. m., December 18, the river at Tempe had fallen to 6 feet, and by 8 a. m., December 19, to 3.5 feet, the Gila River remaining at a low stage.

About the same time the heavy rains in the upper watershed of the Little Colorado River congested that stream and its tributaries to such an extent that on the 16th the water rose rapidly some 25 or 30 feet in the vicinity of Winslow and St. Joseph, Ariz., washing away the railroad tracks for some miles. The damage resulting from these washouts amounted to about \$8,000. Very little, if any, damage resulted from the floods in the Salt and Gila rivers, and the total damage did not amount to more than \$10,000 or \$12,000. The property saved thru the warnings was valued at about \$3,000.

These floods in the Salt River Valley, altho not of great extent, were the greatest since the establishment of the Arizona River and Flood Service in May, 1907, and thus far excellent results have followed the forecasts of floods and marked rises in the streams whose beds are practically dry during six months of the year.

The highest and lowest water, mean stage, and monthly range at 207 river stations are given in Table IV. Hydrographs for typical points on seven principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.—*H. C. Frankenfield, Professor of Meteorology.*

SPECIAL ARTICLES, NOTES, AND EXTRACTS.

THE PRESSURE OF SATURATED VAPOR FROM WATER AND ICE AS MEASURED BY DIFFERENT AUTHORITIES.

By CHARLES F. MARVIN, Professor of Meteorology. Dated December 10, 1908.

Dr. Nils Ekholm has recently published **(1)**[1] the results of a very notable study by him of the maximum pressures of aqueous vapor at different temperatures, as deduced from the observations of all the best authorities. While the present short article on the subject is essentially a review of Doctor Ekholm's paper, yet some details are added from a desire to set forth briefly the present status of our knowledge of this subject. Ekholm has not himself attempted to directly measure vapor pressure, but has brought together the results of the work of many others and has endeavored to eliminate as far as practicable various recognized as well as heretofore neglected minor errors. After harmonizing certain discrepancies and correcting all known errors as far as possible, Ekholm reduces the observations to a homogeneous series of vapor pressures for the whole range of temperature from —50° C., where the pressure is so small it can scarcely be measured, to 365° C., with a corresponding pressure of 200 atmospheres. Ekholm then seeks to represent this long series of observed temperatures and pressures by a single mathematical equation, the form of which is based upon the recognized thermo-dynamic relations between temperature and vapor pressure, as far as these have been set forth by various writers.

The following summary gives briefly the observational data utilized by Exholm:

[1] Heavy-faced numbers in parentheses refer to the bibliography at the end of this article.

Regnault.—The measurements by this great authority **(2)** were made at the College of France between 1840 and 1845, at a time when exact thermometry was almost unknown outside of Regnault's own laboratory, and when the instruments of precision and the multitude of conveniences commonly found in modern laboratories were quite unknown. Nevertheless, Regnault's classic work still constitutes the basis of all vapor pressure tables in common use. He covered a range of temperatures from —30° to +230° C., making in all nearly one thousand separate determinations that in point of skill and care bestowed upon them and in general accuracy of the results are unsurpassed. A similar work done independently by Magnus in Germany fully confirmed the observations by Regnault.

Broch.—Regnault did not escape the commission of certain technical errors in his work, which have been pointed out by Moritz and others, and later, when modern thermometry and manometry had been precisely defined, it became necessary to apply certain small systematic corrections to Regnault's observations. A recomputation with this object in view was very carefully effected by Broch **(3)** in 1881 at the International Bureau of Weights and Measures, and his tables of pressures from —30° to +101° C., are now probably in more general use by meteorologists than any other tables.

The principal source of trouble in Regnault's observations results from the fact that below 100° C. all his temperature readings were made on the so-called normal-mercury-in-glass thermometers. Regnault himself knew that the scale of temperatures thus obtained differed slightly from that of the air thermometer, and from the hydrogen scale, but the corrections between 0° and 100° doubtless seemed small to him, and more

especially was it difficult to establish their value with the same exactitude as in the remainder of his work. Regnault therefore published his results without these small corrections, nor was their application attempted by Broch. The latter collected all of Regnault's observations between —30° and 101° C. (over 500 in number) and combined them into 21 groups, from which he deduced mean values of the pressure at selected points on Regnault's scale of temperatures, i. e., at 10°, 20°, 30°, etc. Broch gives these final values only in the Regnault units of temperature and pressure. They can not therefore be directly and easily compared with other data exprest in standard units. While it is probably impossible at the present time to accurately transform Regnault's values to others on the hydrogen scale of temperatures, they can, however, be easily reduced to normal-mercury-thermometer temperatures and to manometric units under standard gravity by utilizing the data already given by Broch; the method of procedure would be as follows. Broch gives for each of his 21 groups and means of pressures observed by Regnault the difference between the observed value and that calculated by Broch's formula, but all are exprest in Regnault's units. Now, assuming that these differences will be sensibly the same if we deal with values in normal units and adding or subtracting the differences from Broch's tabulated values, I get the values given in Table 3, column 2, under the heading: Regnault by Broch.

Additional remarks on the reduction to the hydrogen scale will be made further on.

Juhlin, Marvin.—Between 1890 and 1891 Juhlin (4) in Upsala and Marvin (5) in Washington independently determined vapor pressures, especially over subcooled water and over ice at temperatures from 0° to —50° C. The observations of both these investigators bring out prominently the difference called for by theory between the vapor pressure over ice, below zero, and the pressure over undercooled water or water at temperatures below its freezing point. Juhlin and Marvin also made some measurements at moderate temperatures above freezing. Ekholm gives the values of Marvin above freezing a prominent place in his adopted series of vapor pressures, and for this purpose the original observations (33 in number, from 32° to 80° F.) were combined into four values at 0°, 10°, 20°, and 30° C. It seems to me that the method Ekholm employed to effect this combination is not the best, and apparently introduces some small errors. Moreover, as Marvin's vapor pressures above freezing have never been published, except in the Annual Report of the Chief Signal Officer, U. S. Army, for 1891, and are not accessible to many students, they are now reprinted in Table 1, and a method is given for deducing values at even temperatures of 10°, 20°, and 30° C. that seem likely to be more accurate than those adopted by Ekholm.

Marvin's original observations on the pressure of vapor over water at temperatures above freezing were made in groups at approximately 5-degree points on the Fahrenheit scale from 35° to 80°, the pressures being measured in millimeters and all necessary reductions made to normal air thermometer temperatures and normal manometer units. Table 1 contains the individual determinations, the mean group-temperatures in Fahrenheit and centigrade units, and the mean pressures. The last column (Marvin minus Broch) gives the departures of Marvin from the values calculated by Broch's formula, which latter differ slightly from Regnault's observed values as reduced by Broch and given in Table 3, column 2.

It will be noticed that the departures, Marvin—Broch, increase progressively and with marked regularity from zero upward. In order to deduce from these results corresponding representative values at the even 10°, 20°, and 30° points on the temperature scale, it seems to the writer that the best way to combine such observations is to plot the departure, and draw a smooth curve thru them as is shown in Chart XI fig. 1. The figures near each plotted point give the number of observations on which that mean value depends, and aid in weighting the respective points. With Broch's formula and this curve of differences we get the values of pressure resulting from Marvin's observations, as shown in Table 2.

TABLE 1.—*Marvin vapor-pressure observations. Above freezing.*

	Temperature.		Pressure.	Marvin minus Broch.
	°*F.*	°*C.*	*Mm.*	*Mm.*
			*4.558	
			4.595	
			4.533	
			*4.562	
			4.554	
			4.586	
			4.575	
			*4.580	
			4.584	
			4.566	
Means of 10 observations (melting ice)	32.00	0.00	4.5683	—0.0004
	34.96		5.164	
	34.95		5.171	
Means of 2 observations	34.96	1.65	5.168	+0.02
	39.44		6.166	
	39.68		6.256	
	40.07		6.297	
	39.70		6.217	
Means of 4 observations	39.72	4.29	6.234	+0.041
	44.78		7.554	
	44.75		7.595	
	44.94		7.614	
Means of 3 observations	44.82	7.12	7.588	+0.061
	49.22		8.947	
	49.86		9.154	
	49.87		9.153	
	50.09		9.239	
Means of 4 observations	49.76	9.87	9.123	+0.062
	54.91		11.080	
	55.18		11.163	
	55.04		11.123	
	55.23		11.151	
Means of 4 observations	55.09	12.82	11.129	+0.122
	59.41		12.993	
	59.80		13.178	
	59.78		13.143	
	59.17		12.904	
	59.99		13.246	
Means of 5 observations	59.63	15.35	13.093	+0.132
	64.76		15.696	
	64.59		15.581	
	64.91		15.764	
Means of 3 observations	64.75	18.19	15.680	+0.166
	69.91		18.747	
	69.58		18.541	
	69.88		18.732	
Means of 3 observations	69.79	20.99	18.673	+0.218
	74.65		21.957	
	75.08		22.268	
	74.93		22.171	
Means of 3 observations	74.89	23.82	22.132	+0.219
	80.05		26.279	
	79.84		26.106	
Means of 2 observations	79.94	26.64	26.192	+0.275

* The braces connect observations made at different times, but with one and the same piece of apparatus.

TABLE 2.—*Marvin's reduction of his own observations of vapor pressure.*

Temperature.	Broch.	Marvin minus Broch.	Marvin.	Marvin as used by Ekholm.
°*C.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
0	4.5687	0.000	4.5683	....
5	6.507	+0.033	6.540	....
10	9.140	+0.078	9.218	9.216
15	12.674	+0.130	12.804	....
20	17.363	+0.186	17.549	17.533
25	23.517	+0.250	23.767	....
30	31.510	+0.315	31.825	31.781

Thiesen and Scheel: 1893.—The observations by these authorities (6) were made at the "Reichsanstalt" or German National Bureau of Standards, and, altho the range of temperatures is very limited (−11° C. to +25° C.), yet the determinations were made with the utmost care and every pains taken to eliminate, as perfectly as possible, the influences of errors. Only two sets of measurements were made below the freezing point, namely, one set at −6.561° C., in which the authors state that the water in the apparatus was frozen, and one set at −11.334° C., for which the water was probably still liquid; but the original paper is not entirely definite as to whether this water was, or was not, frozen. The pressure does not correspond very well with Marvin and Juhlin, but the probability seems to be, and I have assumed that, the water was *not* frozen.

Wiebe: 1893.—The determinations by Wiebe (7) were also made at the Reichsanstalt, and with every possible care; they are given in Table 3, column 3. As in the case of Thiesen and Scheel, the range of temperatures was very limited, but at a higher point on the scale; namely, from 82° C. to 100° C. Thus, Wiebe's measurements serve to fix the values near the boiling point, while Thiesen's fix the values at and near the freezing point.

Landolt and Börnstein: (8).—In the new edition of the Landolt-Börnstein Physikalisch-Chemische Tabellen (Berlin, 1905, pages 118–122), Regnault's and Broch's vapor pressure tables have been recomputed with corrections and adjustment of the values so as to incorporate the results of Juhlin, Marvin, Thiesen and Scheel, and Wiebe, and finally to reduce temperatures to the hydrogen scale. Just how all these results have been effected and what equations and constants have been employed, are not explained.

Regnault gave numerous comparisons of his mercury thermometers with the gas thermometer at temperatures above the boiling point, where the differences are large, and altho he states that these thermometers read lower than the gas thermometer between zero and 100° C., yet carefully determined differences were not published. In discussing this subject Wiebe computed the corrections to Regnault's thermometers between 0° and 100° C., by using an equation the constants of which were determined by observations above 100° C. Ekholm seems also to have followed this course in the reductions he made of Regnault's observations between zero and 100° C., but eventually Regnault's results within these limits were not used by him.

Pressures at high temperatures.—In addition to the abovementioned observations made by Regnault at temperatures above the boiling point, several other series have been executed with more or less exactness and the range of temperatures considerably extended, so as to include especially the condition in the neighborhood of the so-called critical temperature and pressure; that is, at about 365° C. and a pressure of 200 atmospheres.

Three series of observed pressures at high temperatures are available, as follows:

Ramsay and Young (9).—These cover the range of temperatures from 120° to 270° C.; that is, about 40° higher than observed by Regnault, and probably mark the upper limit of conditions under which steam is useful in operations of practical steam engineering.

Battelli (10), *Cailletet and Colardeau* (11).—These two remaining series of vapor pressure determinations were made in Italy and France, respectively, and extend the range to the critical temperature and pressure beyond which the customary distinctions between liquid and vapor state no longer exist.

Those who have consulted Regnault's original memoirs will recall that for purposes of interpolation he plotted with great accuracy many of his observations (about one-third, he himself says) directly upon a great copper plate, with centimeter lines engraved thereon, and provided with a device to accurately subdivide these centimeter squares. Regnault's tabulated results, as well as the modern revised tables at high temperatures based thereon, are derived directly from these curves. Ekholm calls attention to important discordances between results from the curves and observations not plotted, and he revises all the observations combining them at 10° points on the temperature scale; the latter he reduces to standard units and the pressures to normal gravity.

We need not comment further upon this large mass of valuable observational data, and in order to enable the reader to estimate for himself the relative merits of the different investigations we give in Table 3 a summary of all the observations on a strictly comparable basis. Ekholm's accepted values appear in column 6. He regarded Juhlin's values over ice too large on account of a small capillary error and subtracted .027 millimeter from each to correct for the same. Column 3 contains the values thus obtained, which are almost identical with Marvin's values. Ekholm's accepted values in column 6 are the mean of these two after altering Marvin's readings by .001 or .002 millimeter to eliminate a supposed effect due to the unequal pressure of the mercury vapor in the manometer. At +10° C., also, Juhlin's and Marvin's values are identical. At 20° and 30° C. Marvin's values only are used by Ekholm. All these results are given a weight of 10. None of the Regnault data below 100° C. is used, nor the values of Thiesen and Scheel. The latter, however, agree so nearly with those used, that their omission or inclusion, unless excessively weighted, would make very little difference. Observations are wanting above 30° C. until we come to Wiebe's results from 80° to 100° C. These are given a weight of 400. Above 100° C. Regnault's values are weighted 10; Ramsey and Young, Battelli, and Cailletet and Colardeau, each 1. Ekholm constructs from this material the set of values given in Table 3, column 6, which may be considered as observational results accepted by him for further study.

Holborn and Henning.—The work of these writers (12) has only recently been published and was not available to Ekholm, but their results are included here for comparison with others. This series of measurements was made at the Reichsanstalt and embraces a range of conditions from 50° to 200° C. It is needless to say that all the precautions known to modern science were observed, to eliminate and to correct for influences of errors from all sources.

As in the case of Regnault's observations the pressures were measured with a great mercurial manometer, having in this case a total height of 12 meters, and extending upward thru several stories of the laboratory. A notable feature of this investigation is the use of electrical resistance thermometers in the determination of temperature. Elaborate care was taken to establish accurately the constants of these platinum resistance thermometers, and the relation of the temperatures thus obtained to those of the nitrogen thermometer. The temperatures were all finally reduced to the thermodynamic scale. The results of this investigation are given in column 10 of Table 3.

For completeness we add the following values, exhibiting our present knowledge of the relation between the hydrogen and the thermodynamic scales. We quote from a letter of Dr. Edgar Buckingham of the Bureau of Standards:

According to D. Berthelot (Travaux et Memoires, Bureau International du Poids et Mesures, Tome XIII, p. 101), the constant-volume hydrogen thermometer, with an initial pressure of 1,000 millimeters of mercury at the ice point, reads lower than the thermodynamic scale by the following amounts:

° C.	° C.
−100	+0.008
0	0.000
+ 40	−0.00055
+ 60	−0.00052
+100	0.000
+200	+0.003
+300	+0.007
+400	+0.013

It is probable that in the present state of thermometry the differences of the two scales are absolutely negligible.

TABLE 3.—*Maximum pressure of aqueous vapor over water and ice as found by different authorities.*

1 Temperature.	2 Regnault by Broch.* Water.	3 Juhlin by Ekholm. Ice.	3 Juhlin by Ekholm. Water.	4 Marvin. Ice.	4 Marvin. Water.	5 Thiesen and Scheel. Ice.	5 Thiesen and Scheel. Water.	Ekholm. 6 Accepted observations. Ice.	Ekholm. 6 Accepted observations. Water.	Ekholm. 7 Weights.	Ekholm. 8 Calculated and adopted. Ice.	Ekholm. 8 Calculated and adopted. Water.	Ekholm. 9 Observed minus the calculated.	10 Holborn and Henning.*
°. C	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.		Mm.	Mm.	Mm.	Mm.
−50		0.029		0.030				0.030		10	0.031		− 0.001	
−40		0.094		0.100				0.096		10	0.100		− 0.004	
−30	0.3538	0.284		0.284				0.285		10	0.293		− 0.008	
−20	0.8210	0.779		0.781				0.782		10	0.788		− 0.006	
−10	2.0272	1.969	2.165	1.961	2.156		2.136	1.963	2.165	10	1.968		− 0.005	
−5				3.009	3.164	3.050					3.033			
0	4.5686		4.572		4.568		4.579		4.571	10		4.604	− 0.033	
+5					6.540							6.566		
10	9.0888		9.216		9.218				9.216	10		9.234	− 0.018	
15					12.804		12.778					12.817		
20	17.3645				17.549		17.520		17.533	10		17.568	− 0.035	
25					23.767		23.683					23.797		
30	31.5309				31.825				31.781	10		31.873	− 0.092	
40	54.8970											55.401		
			11 Wiebe.											
50	91.9326											92.641		92.30
60	148.9160											149.575		149.19
70	233.4807											233.932		233.53
75	288.5221											289.350		289.0
80	354.8948		355.50						355.50	400		355.438	+ 0.06	355.1
85	433.5677		433.68						433.68	400		433.757	− 0.08	433.5
90	525.2701		526.11						526.11	400		526.021	+ 0.09	525.8
93	587.9580											588.842		588.7
95	633.4407		634.18						634.18	400		634.095	+ 0.08	634.0
97	681.9741											682.199		682.1
99	733.4244											733.291		733.3
100	759.7944		760.00						760.00	∞		760.000	0.00	760.00
101	784.2350													

1 Temperature.	12 Regnault.	13 Ramsay and Young.	14 Battelli.	15 Cailletet and Colardeau.	6 Accepted observations.	7 Weights.	8 Calculated and adopted.	9 Observed minus the calculated.	10 Holborn and Henning.*
110									
120	1491.00	1484			1490.4	11	1488.3	+ 2.1	1488.9
125				1672	1672.0	1	1737.6	− 65.6	1744.5
130	2026.48	2019	2043		2027.2	12	2024.4	+ 2.8	2025.6
140	2708.30	2694			2707.0	11	2707.6	− 0.6	2709.5
145			3129		3129.1	1	3113.0	+ 16.1	3115.3
150	3567.36	3568		3572	3567.8	12	3565.8	+ 2.0	3568.7
160	4636.55	4652			4638.0	11	4629.8	+ 8.2	4633.
170	5949.77	5937			5948.6	11	5932.9	+ 15.7	5937.
175				6688	6688.	1	6685.5	+ 2.5	6689.
180	7531.76	7487†			7527.7	11	7511.7	+ 16.0	7514.
185			8360		8360.	1	8416.9	− 56.5	8417.
190	9408.63	9403			9408.1	11	9405.1	+ 3.0	9404.
200	11651.53	11625	11635	11628	11646.4	13	11655.2	− 8.8	11647.
210	14292.48	14240			14287.7	11	14306.6	− 18.9	
220	17341.30	17365			17343.5	11	17406.6	− 63.1	
225				19076	19076.	1	19140.2	− 64.2	
230	20924.47	20936	(20738)		20925.5	11	21004.9	− 79.4	
240		25019			25019.	1	25155.8	− 136.8	
250		29734		29792	29763.	2	29914.6	− 151.6	
260		35059			35059.	1	35339.9	− 280.9	
270		41101			41101.	1	41493.6	− 392.6	
275				45144	45144.	1	44864.0	+ 280.0	
300				65512	65512.	1	64991.4	+ 520.6	
310			(78290)		78290.	1	74740.5	+(3549.5)	
325				92416	92416.	1	91427.7	+ 988.3	
335			(106814)		106814.	1	104048.	+(2766.)	
350				127300	127300.	1	125044.	+ 1855.	
360			140815		140815.	1	141486.	− 671.0	
365			149707	152380	151043.5	2	150078.	+ 965.5	

All pressures are exprest in standard manometric units.

* The values in column 2 are for temperatures on the Regnault normal mercury-in-glass thermometer; those in column 10 are on the thermodynamic scale. All other values are on the hydrogen scale.

† Dr. A. D. Risteen in "The Locomotive," April, 1907, p. 187, a pamphlet published by the Hartford Steam Boiler Inspection and Insurance Company, Hartford, Conn., calls attention to an obvious mathematical error in respect to this value in the original paper. The correct value is 7478.

VAPOR PRESSURE FORMULA.

Many attempts have been made to formulate a vapor pressure equation based on what is known of the thermodynamic relations between the pressures and temperatures of vapors, and a considerable degree of success has been realized in certain cases. The calculated values on the whole, however, do not agree with the observed pressure with sufficient accuracy to satisfy many demands. The numerical tables for pressure of aqueous vapor now in general use are derived either directly from observations or from equations having different forms and different constants for different parts of the temperature range.

Ekholm has endeavored to embrace the entire range of pressures within the scope of a single equation. He recognizes, however, the differences which both experiment and theory call for between vapor pressures over ice and over water.

Ekholm has not limited himself to one form of equation, nor to a single set of constants, but gives such a variety of results as to leave the reader a little puzzled as to which to select as the best.

For a preliminary study he tries the following equation, derived from studies by Clapeyron and Clausius:

$$\frac{dp}{dt}=\frac{Er}{T(s-\sigma)} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

p=vapor pressure over fluid water in dynes per square centimeter; T=absolute temperature; E=the mechanical equivalent of heat; r=latent heat of evaporation; and s and σ=the volume of a unit weight of vapor and water, respectively; all in C. G. S. units.

Not satisfied with the results obtained from this equation, Ekholm sought by trial to find some sufficiently simple func-

TABLE 4.—*Showing pressures accepted by Ekholm as derived from various observers, with the differences in millimeters and in percentages between various equations and authorities*

Temperature.	Accepted pressures by Ekholm.		Accepted pressures minus equation (18), (Ekholm).		Accepted pressures minus equation (20), (Ekholm).		Accepted pressures minus equation (37), (Clausius.)		Accepted pressures minus Broch, —30° to 100°. / minus Regnault, 100° to 230°.		Accepted pressures minus Landolt and Börnstein, 1905.		Accepted pressures minus Holborn and Henning, 1908.	
	Pressure.	Weight.												
°C.	Mm.		Mm.	%	Mm.	%	Mm.	%	Mm.	%	Mm.	%	Mm.	%
—50	0.039	10	— 0.001	—3.33	±0.000	±0.00	+ 0.001	+3.33			— 0.004	—13.33		
—40	0.096	10	— 0.004	—4.17	—0.002	—2.08	± 0.000	±0.00			— 0.009	— 9.38		
—30	0.285	10	— 0.008	—2.81	—0.003	—1.05	+ 0.001	+0.35	— 0.095	—33.3	— 0.007	— 2.46		
—20	0.782	10	— 0.006	—0.77	+0.004	+0.51	+ 0.009	+1.15	— 0.162	—20.7	— 0.005	— 0.64		
—10	1.963	10	— 0.005	—0.26	+0.012	+0.62	+ 0.016	+0.82	— 0.188	— 0.6	— 0.011	— 0.56		
0	4.571	10	— 0.033	—0.72	—0.008	—0.18	— 0.008	—0.18	+ 0.002	+ 0.04	— 0.008	— 0.18		
+10	9.216	10	— 0.018	—0.19	+0.014	+0.15	+ 0.004	+0.04	+ 0.076	+ 0.08	+ 0.037	+ 0.40		
20	17.534	10	— 0.035	—0.20	—0.001	—0.01	— 0.023	—0.13	+ 0.070	+ 0.04	+ 0.127	+ 0.73		
30	31.781	10	— 0.092	—0.29	—0.059	—0.19	— 0.099	—0.31	+ 0.271	+ 0.09	+ 0.226	+ 0.71		
40														
50														
60														
70														
80	355.50	400	+ 0.06	+0.02	±0.00	±0.00	— 0.05	—0.01	+ 0.63	+ 0.18	+ 0.03	+ 0.01	+ 0.40	+0.11
85	433.68	400	— 0.08	—0.02	—0.14	—0.03	— 0.17	—0.04	+ 0.49	+ 0.11	— 0.11	— 0.02	+ 0.18	+0.04
90	526.11	400	+ 0.09	+0.02	+0.03	+0.01	+ 0.04	+0.01	+ 0.64	+ 0.12	+ 0.11	+ 0.02	+ 0.31	+0.06
95	634.18	400	+ 0.08	+0.01	+0.05	+0.01	+ 0.06	+0.01	+ 0.52	+ 0.08	+ 0.09	+ 0.01	+ 0.18	+0.03
100	760.00	∞	± 0.00	±0.00			± 0.00		± 0.00		± 0.00		± 0.00	
110														
120	1490.4	11	+ 2.1	+0.14			+ 2.3	+0.16	— 0.9	— 0.01	— 0.6	± 0.00	+ 1.5	+0.01
125	1672.0	1	— 65.6	—3.93			— 65.3	—3.91	—71.9	— 4.31	—72.	— 4.31	—68.5	—4.10
130	2027.2	12	+ 2.8	+0.14			+ 3.2	+0.16	— 3.1	— 0.15	— 2.8	— 0.14	+ 1.6	+0.08
140	2707.0	11	— 0.6	—0.02			— 1.0	—0.04	—10.6	— 0.39	—11.0	— 0.41	— 2.5	—0.09
145	3129.1	1	+ 16.1	+0.50			— 16.5	—0.53	+ 3.6	+ 0.12	+ 4.1	+ 0.13	+13.8	+0.44
150	3567.8	12	+ 2.0	+0.06			+ 2.6	+0.07	—13.4	— 0.38	—13.2	— 0.37	— 0.9	—0.03
160	4638.0	11	+ 9.2	+0.17	+ 8.7	+0.19	+ 8.4	+0.18	—13.6	— 0.29	—13.0	— 0.28	+ 5.0	+0.11
170	5948.6	11	+ 15.7	+0.26			+ 15.2	+0.26	—13.1	— 0.22	—12.4	— 0.21	+12.0	+0.20
175	6688.	1	+ 2.5	+0.04			— 1.6	—0.02	—29.4	— 0.44	—29.0	— 0.43	+ 1.	+0.01
180	*7526.0	11	+ 16.0	+0.21			+ 14.5	+0.19	—19.5	— 0.26	—19.1	— 0.25	+13.	+0.17
185	8360.0	1	— 56.5	—0.68			— 58.7	—0.70	—93.2	— 1.11	—93.0	— 1.11	—57.	—0.68
190	9408.1	11	+ 3.0	+0.03	+ 2.7	+0.03	± 00.0	±0.00	—34.6	— 0.37	—33.9	— 0.36	+ 4.	+0.04
200	11646.4	13	— 8.8	—0.08			— 15.1	—0.13	—42.6	— 0.37	—41.6	— 0.36	+ 0.6	+0.01
210	14287.7	11	— 18.9	—0.13			— 28.5	—0.20	—37.1	— 0.26	—36.3	— 0.25		
220	17343.5	11	— 63.1	—0.36	— 99.2	—0.57	— 78.1	—0.45	—46.9	— 0.27	—45.5	— 0.26		
225	19076.	1	— 64.2	—0.34			— 83.1	—0.44	—21.0	— 0.10	—20.0	— 0.10		
230	20925.5	11	— 79.4	—0.38			—102.1	—0.49			+ 0.5	+ 0.00		
240	25019.	1	—136.8	—0.55			—168.7	—0.67						
250	29763.	2	—151.6	—0.51	—197.1	—0.66	—202.3	—0.68						
260	35059.	1	—280.9	—0.80			—340.9	—0.97						
270	41101.	1	—392.6	—0.96			—472.0	—1.15						
275	45144.	1	+280.0	+0.62			+188.0	+0.42						
300	65512.	1	+520.6	+0.79	+194.5	+0.30	+351.3	+0.54						
310	78290.	1	+(3549.5)	+4.53			+(3338.)	—4.27						
325	92416.	1	+988.3	+1.07			+706.	+0.76						
335	106814.	1	+(2834.)	+2.66			+(2401.)	+2.25						
350	127300.	1	+1855.	+1.46			+1357.	+1.07						
360	140815.	1	—671.	—0.48			—1286.	—0.91						
365	151043.5	2	+965.5	+0.64	+ 1.5	+0.01	+280.	+0.19						

* Corrected for error explained in foot note, table 3.

tion of pressure and temperature that would satisfy the observations, and for this purpose gave equation (1) the following form:

$$T\frac{d\log f}{dt}=\frac{E}{p(s-\sigma)},$$

which he considers better adapted to the requirements of the problem. After a number of transformations he obtains the following final form[1]:

$$\log f=\log 760+A\log\frac{a+t}{a+100}+B(\mathrm{li}\,x-\mathrm{li}\,X)+C(\mathrm{li}\,x-\mathrm{li}\,X),\quad(9)$$

where x and X are exponential functions of the absolute temperature of the following form:

$$\left.\begin{aligned}x_t&=10^{-k(a+t)}\\X_t&=10^{-l(a+t)}\end{aligned}\right\}\quad\ldots\ldots\ldots\ldots\ldots\ (16)$$

The expression "li" signifies the "integral logarithm" of the function between limits. Such an equation is troublesome in its computation because it requires the use of Ekholm's extended table of values of the integral logarithms.

The constants for formula (9) as derived by a least-squares analysis from the "accepted" data in column 6 of Table 3, are as follows for water vapor:

		Logarithm:	
k	$= 0.00281644$		
l	$= 0.00821902$		
A	$= 6.19373$	0.791952	
B	$= 34.5868$	1.538910	(18)
C	$= -2.742$	0.4381 neg.	
	$a = 272.6684°$ C.		

[1] We number the equations to agree with Ekholm's notations.

These constants, for water vapor substituted in equation (9) with necessary alteration for ice, to be explained later, give the calculated values in column 8 of Table 3, and have been adopted by Ekholm for the computation of extensive tables.

In equations (9) and (18) the constant a is the absolute temperature of the freezing point of water, that is to say the reciprocal of the coefficient of expansion for such gases as hydrogen, which, according to Broch, leads to the value $a=272.6684°$ C. It is frequently customary to use the whole number $a=273°$ C. Accordingly, Ekholm computed a new set of constants for equation (9), based on this latter value of a. These he designates (19), but they need not be given here as the pressures by the equation, do not differ from those by the old as much as a thousandth of a millimeter, except at high temperatures where the differences are very small.

Finally, Ekholm selects: (1) the value of $f=4.579$ millimeters at 0° C. as measured with such elaborate care by Thiesen and Scheel; (2) the correspondingly carefully determined value $f=355.50$ millimeters at 80° C. by Wiebe; and (3) the mean value $f=153378$ millimeters at 365° C. from measurements of Battelli, Cailletet and Colardeau. With these three observations, still retaining $a=273°$ C. and two of the minor constants from set (19), new values of the constants A, B, and C were computed. The results, in full, are—

		Logarithm:	
k	$= 0.00281689$		
l	$= 0.0076323$		
A	$= 6.24086$	0.795244	
B	$= 34.3398$	1.535798	(20)
C	$= 7.33081$	0.865151	
	$a = 273.00°$ C.		

We shall presently show more fully the differences between the observed pressures and the calculated values by these equations. Considering the close agreement realized and the labor involved in these tedious computations, we might have expected Ekholm to stop at this point. However, he also studies an additional equation (37) previously employed by Clausius, but with inaccurate constants derived from insufficient data. The original equation of Clausius is

$$\frac{P}{RT}=\frac{1}{v-a}-\frac{1}{\theta(v+\beta)^2} \tag{21}$$

where P, T, and v are pressure, absolute temperature, and volume respectively; R and a are constants, and θ is a function of the temperature of which it is only stated that when $T = 0°$ C, $\theta = 0°$, and when $T =$ the critical temperature,

$$\theta = \frac{8}{27(\beta + a)}.$$

Important transformations are required to evaluate v and θ, but we shall not give these here. For the calculation of the constants of this equation Ekholm employs only three observations, namely: Thiesen and Scheel's value at freezing, $T = 273°$ C, $f = 4.579$ mm.; the pressure 760 mm. required by definition at the boiling point, $T = 373°$ C; and finally, the pressure and temperature at the critical point as deduced from the observations of Battelli and Cailletet and Colardeau, viz: $T = 637.65°$ C, $f = 150\,140$ mm. The equation resulting from these computations is designated "(37)" by Ekholm.

All the foregoing equations apply strictly to vapor over water. In Juhlin's experiments, a large number of measures were made with a differential manometer which gave directly the difference in pressure of vapor over water and vapor over ice at the same temperature. Arrhenius (12) has shown that these can be closely represented by the following simple equation:

$$\log f_{ice} = \log f_{water} + 0.004147\,t,$$

which Ekholm uses in connection with the equations already considered, and obtains values of vapor pressure over ice corresponding to the particular equation and constants employed for the calculation of f_{water}.

AGREEMENTS BETWEEN OBSERVED AND CALCULATED VALUES.

In Table 4 we give, first, in columns 1, 2, and 3, the observations accepted by Ekholm, Table 3, column 6, with their weights. In the remaining columns are given the differences between these accepted values and those calculated by the different equations. The differences are given in millimeters of pressure and also as percentages of the pressure. Since Broch's tables below 100° C have been and are still used so extensively in meteorological and physical work, and Regnault's tables above 100° in steam engineering problems, the differences between Ekholm and these authorities are included, likewise the differences from the Landolt and Börnstein tables, and from the Holborn and Henning tables.

In considering the relative merits of the several formulas we need to keep in mind that at low temperatures, say below 15° C., the inaccuracy in observations is chiefly caused by inaccuracy in the measurement of the *pressure*, as distinguished from the measurement of *temperature*. Errors in pressure of several thousandths, possibly of some hundredths of a millimeter can hardly be avoided in individual observations. At higher temperatures, on the other hand, the the limit of accuracy is chiefly dependent upon the errors of temperature measurements which, at the best, amount to at least one one-hundredth of a degree, and even some tenths of a degree at the highest temperatures.

The following values of dp when $dt = 0.1°$, will aid in interpreting Table 4:

Differences in pressure for a difference of 0.1° C.

Temperature (° C.)	—50	0	50	100	200	350
dp (in millimeters)	=0.003	0.033	0.46	2.71	24.4	153.

To bring out most forcibly the important information contained in Table 4 we require a diagram of the differences as shown in Chart XI, figs. 2 and 3, for example. To make the diagram clear in all its parts it has been necessary to use different scales for different portions. While the absolute values of the differences are very small at temperatures below zero, their percentage values are considerable. Whereas, between 80° and 100° the percentage differences are so small as to require an exaggerated scale to show them. The differences for some of the observations, above 100°, are so great they can not be included in the limits of a diagram that is suitable for the good observations.

The first generalization brought out from a study of Table 4 and the curves of Chart XI, fig. 2, is that below the freezing point the discrepancies between observation and calculation by equations (18) and (20), attain to a maximum of about 4 per cent at —40° C., but between this point and 30° C. the discordances are less than 1 per cent in every case, and in general are only a few tenths of a per cent. Between 80°C. and 100°C. the differences between the accepted and calculated pressures are only a few hundredths of a per cent, except those from Broch's table which run from one to two tenths of a per cent lower than Wiebe's observations. To bring out these small differences the scale of the diagram, Chart XI, fig. 2, between 80° C. and 100° C. is exaggerated as indicated by the numbering. The absence of observations between 30°C. and 80°C. leaves an element of doubt with respect to the exact value of vapor pressures for this region, so important to the meteorologist and physicist.

Above 100°C. the curves of Chart XI, fig. 3, up to 230°C., pass thru points determined from the observations and having a weight of 11 or more. From 230°C. to 270°C. the points refer to the observations by Ramsay and Young, and beyond this limit the points are located by the observations of Cailletet and Colardeau.

The first observation by Cailletet and Colardeau at 125°C. is widely discordant and falls outside the limits of the diagram. Several of the observations by Battelli, as at 145° and 180°C., and more notably those inclosed within parentheses in Tables 3 and 4 (namely, at 230°, 310°, and 335°C.) are all seriously discordant from the other observations, but, nevertheless, were included by Ekholm in his computations.

Those of Battelli's discordant differences that can be located within the limits of the diagram, Chart XI, fig. 3, are marked thus: $\binom{B}{\times}$. These curves bring out in a striking manner the very close agreement below 230°C. between the observations of Regnault and Ramsay and Young; but above 270°C. the observations by Cailletet and Colardeau, and those of Battelli are not in equally close accord.

Regarding the several equations Ekholm remarks, on page 34:

> The constants (18) or (19), as likewise (20), give so close an agreement between the observed and calculated values of f that there is no ground on which to prefer one over the other, and I have therefore retained the tables computed from (18), the more so since computations by Clausius' method, (see the next section), give very nearly the same values.

I think a close scrutiny of Table 3 and the curves of Chart XI will lead one to take exception to this conclusion. The vapor pressure at the freezing point has been determined with exceeding care by many observers. The values observed by Regnault, Juhlin, Marvin, Thiesen and Scheel agree within one-quarter of 1 per cent or less; whereas, equation (18) gives a value nearly 1 per cent higher than the average of the observations. Furthermore, the values calculated by (18) are systematically too high below 30°C., and also between 80° and

100°C., altho the differences have a small percentage value, especially in the latter case.

Tables of vapor pressure over the lower range of temperatures are used daily by meteorologists and they will hardly feel satisfied with a systematic discordance of the kind we have pointed out, which doubtless results in part at least from extending each individual equation over the extreme range of temperature.

The constants composing equations (20) do not result from a least-square computation that includes the whole series of observations, but depend chiefly on observations at temperatures 0°, 80°, and 365°C. Nevertheless, the calculated values below 60°C., especially over the meteorological range of temperatures, are in closer agreement with the observations than in the case of equation (18). Between 100° and 200°C. equation (20) gives values that agree with the observations quite as well as those from (18). Above 200° C. the differences are somewhat in doubt, as Ekholm has given values at only a few points. On the whole, the results favor the adoption of equation (20) rather than (18).

The constants of the Clausius equation (37) depend likewise on only three observations, in fact, only on two, namely, at 0°, and the critical temperature 364.65°C. since at the third point used, the boiling point, the pressure by definition must be 760.00 millimeters and this does not rank as an observation. This equation, nevertheless, agrees very closely with the observations and with (20) below +30°C. Between this point and 100°C. it runs appreciably higher than either (20) or (18), both of which seem higher than the observations.

The vapor pressures in Broch's tables below 0°C. must be regarded as pressures over undercooled water and are too high to be applicable to vapor over ice. Between 0° and 30°C. the values run slightly smaller, nearly one-tenth of 1 per cent, than Ekholm, but near 100°C. the discrepancies are larger. The Landolt and Börnstein table, edition 1905, is seriously discordant with Ekholm below —30°, but between —30° and 100°C. the agreement is closer than in the case of the Broch tables. All values are smaller than Ekholm's.

The Thiesen-Scheel and the Holborn-Henning observations from 0° to 100° are also smaller than the values calculated by Ekholm's formulas. We must, therefore, conclude that for meteorological work the values calculated by equations (9) and (18) and adopted by Ekholm for his extended tables are systematically slightly too high, as shown by all the best observations.

Above 100° we find the three Ekholm equations all in close accord with each other and the observations, up to about 200°C. Beyond this point the equations give values systematically and increasingly higher than the observations up to 270°C., at which temperature the observations by Ramsay and Young terminate. A marked discontinuity in the trend of the curves is required at this point to join with the observations by Cailletet and Colardeau, and we are compelled to regard the observations themselves between 270° and 365° C. as much less exact than for the lower temperatures.

The observations by Holborn and Henning are probably more accurate than any others over the range of temperatures from 100° to 200°C, and it is of great interest to notice how closely the results agree with Regnault's values determined over half a century earlier. The values last found are systematically smaller than Henning's reduction of Regnault's observations, but the maximum difference, exprest in temperatures, amounts to only 0.02° at any point; that is, less than 0.06 per cent at 140°C., and still smaller percentages at higher temperatures.

A further point of great interest is revealed from a comparison, in fig. 3, of the trend of the curves for Ekholm's equations, and that representing Holborn and Henning's work. These several curves follow each other from 80° to 200°C. in a very striking manner, and the inference is that if the Holborn and Henning values had been available to Ekholm his observed and calculated values would have shown a still closer agreement within this range of temperatures than is at present the case.

2——2

In conclusion it may be remarked that the systematic differences between observed and calculated values thruout what we may call the meteorological range of temperatures can not be accepted as entirely satisfactory. This, in some measure, must be caused by the effort to represent the pressures for the entire range of temperatures by one equation which is at least partly empirical. While, from the point of view of pure theoretical thermodynamics, only one equation is required, yet in the matter of practical application it is a question whether better results could not be secured by the use of two equations; one with constants, giving the best agreement with observations below 100°, due regard being paid below freezing to the difference between vapor over ice and over undercooled water, and the other equation adapted to conditions above 100°C. This alternative is, of course, preferable only on the assumption that the objections to the single equation can not be eliminated.

We have noticed a few errata in Ekholm's Table 7, namely: The differences in the last column should be, it seems, as follows:

At 0°, —.033 instead of —.031,
At 170°, +8.2 instead of +9.2,
At 340°, +2766. instead of +2834.

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12. **Holborn L. and Henning F.** Ueber das Platinthermometer und den Sättigungsdruck des Wasserdampfes zwischen 50° und 200°. (Mitteilung aus der Physikalisch-Technischen Reichsanstalt). Annalen der Physik. 4te Folge. Band 26. No. 10, pp. 833-883.

NOTES FROM THE WEATHER BUREAU LIBRARY.

By C. Fitzhugh Talman, Librarian.

INTERNATIONAL COMMISSION ON SCIENTIFIC AERONAUTICS.

H. H. the Prince of Monaco, who is an honorary member of the International Commission on Scientific Aeronautics, has

invited the commission to hold its next triennial meeting at Monaco April 1 of this year. It is proposed to hold the sessions in the rooms of the Oceanographic Museum. The last meeting was held at Milan in 1906.

This commission suffers under a somewhat misleading name, as it is not especially concerned with aeronautics—i. e., the navigation of the air—but has for its sphere the whole subject of upper air meteorology. Inasmuch as the term "aerology" is now quite generally applied to this branch of meteorology, the writer of these notes ventures to suggest that the commission ought to be renamed "International Aerological Commission;" especially as there exists another international organization for the discussion of purely aeronautical questions; viz, the Commission Permanente Internationale d'Aéronautique.

This commission—i. e., the one devoted to "aerology"—has a membership of 55, and is the largest of all the commissions on special subjects appointed by the International Meteorological Committee. Its president is Prof. H. Hergesell, director of the Meteorological Service of Alsace-Lorraine.

INTERNATIONAL COMMISSION ON DAILY WEATHER REPORTS FOR THE GLOBE.

Another meteorological commission is to meet at Monaco in April; viz, the commission appointed at the last Paris meeting of the International Meteorological Committee to consider Teisserenc de Bort's plan of securing prompt reports, day by day, from about 30 selected stations in various parts of the globe, and the suggestion of Hildebrandsson that observatories be established at the "centers of action" of the atmosphere. This commission will begin its sessions just after those of the Commission on Scientific Aeronautics, viz, April 5, 1909. The adoption of the project of MM. Teisserenc de Bort and Hildebrandsson would enable the central office of each national weather service to keep *en rapport* with current meteorological conditions in other parts of the globe, and especially in those regions where the phenomena of the atmospheric circulation are believed to be of the greatest significance to the weather of the world at large. So far as the Weather Bureau is concerned, it would facilitate the enlargement and improvement of our synoptic weather map of the Northern Hemisphere, now made every day at Washington from telegraphic reports.

The members of this commission are: Teisserenc de Bort (president), Hildebrandsson (secretary), Hergesell, Deslandres, Hellmann, Lyons, Shaw, and Walker.

METEOROLOGICAL APPOINTMENT IN BELGIUM.

It is announced that J. Vincent has been appointed director of the meteorological service of the Royal Observatory of Belgium—i. e., of the Belgian national weather service—to succeed the late Albert Lancaster. M. Vincent has been prominently connected with the Belgian service for many years, and has been director *ad interim* since the death of M. Lancaster; hence his appointment to the directorship was in the natural order of events.

A COURSE IN METEOROLOGY FOR BALLOONISTS.

A five-hour course in meteorology for balloonists and others interested in aeronautics, covering the months of January and February, has been established at Cologne under the auspices of the aeronautical club of that city. The lectures are given at the Handelhochschule, by Doctor Polis, director of the meteorological observatory of Aix-la-Chapelle.

HOMAGE TO PROFESSOR HANN.

Meteorologists all over the world unite this year in doing honor to Hofrat Prof. Dr. Julius Hann, of Vienna, who completes his 70th year on March 23. At the instance of Prof. Wilhelm Trabert, the photographs of prominent meteorologists of all countries have been collected at Vienna, and will be presented to Professor Hann on his birthday.

DR. PAUL BERGHOLZ, 1845-1909.

Dr. Paul Bergholz, director of the meteorological observatory at Bremen, died January 3, 1909. Doctor Bergholz took charge of the second-order station at Bremen in 1889, caused it to be raised to the rank of an observatory the following year, and thereafter, up to the time of his death, carried on the observations that have been published in such elaborate detail as a separate annual volume, for Bremen, of the "Deutsches meteorologisches Jahrbuch." He also collected and published several early series of observations at Bremen, extending back to the year 1803.

Other publications by Doctor Bergholz related to tropical hurricanes, including a substantial volume, "Die Orkane des ferne Ostens" ("The hurricanes of the far east"), based on the first edition of Algué's well-known treatise on that subject.

OFFICERS OF THE ROYAL METEOROLOGICAL SOCIETY FOR 1909.

At the annual meeting of the Royal Meteorological Society on January 20, the following officers and members of the council were elected for the ensuing year:

President, Lieut.-Col. H. Mellish; Vice-Presidents, Mr. W. W. Bryant, Mr. W. H. Dines, F. R. S., Commander M. W. Campbell Hepworth, C. B., Dr. H. R. Mill; treasurer, Dr. C. Theodore Williams; secretaries, Mr. F. C. Bayard, Commander W. F. Caborne, C. B.; foreign secretary, Dr. R. H. Scott, F. R. S.; council, Messrs. R. Bentley, F. J. Brodie, C. J. P. Cave, Dr. H. N. Dickson, F. Druce, E. Gold, R. Inwards, B. Latham, R. G. K. Lempfert, Col. H. E. Rawson, C. B., Capt. R. C. Warden, and Capt. D. Wilson-Barker.

AEROLOGICAL STATIONS OF THE WORLD.

The Wiener Luftschiffer Zeitung for February 1, 1909, publishes a complete list of the upper air observations made on the "international days" during the first half of the year 1908. From this list we learn that observations with kites or balloons (or both) were made more or less regularly at the following places:

Trappes, France; Uccle, Belgium; DeBilt (near Utrecht), Holland; Pyrton Hill, Petersfield, Brighton, Glossop (near Manchester), England; Pavia, Italy; Guadalajara, Spain; Zürich, Switzerland; Strassburg, Frankfort a M., Hamburg, Lindenberg, Munich, Friedrichshafen (the kite station on Lake Constance), Germany; Vienna, Austria; Pavlovsk, Kasan, Koutchino, Ekaterinburg, Nijni Olchedaev, Tiflis, Baku, Kovno, Russia; Helwan, Egypt; Blue Hill (Mass.), Mount Weather (Va.), United States.

The above is not a complete list of the aerological stations of the world, but will convey some idea of the extensive scale upon which the campaign of upper air research is now being conducted.

SUMMER AND WINTER VERTICAL TEMPERATURE GRADIENTS.

By W. J. Humphreys, Professor of Meteorological Physics.
Dated Mount Weather, February, 1909.

In my article on the vertical temperature gradients of the atmosphere, Vol. II, No. 1, of the Mount Weather Bulletin, I state that the effect of change of season on this gradient causes it to be greatest in winter and least during the summer, and that this condition is best seen at a considerable elevation, since in the turbulent region next the earth storms and other temporary results mask those due to seasonal change.

The gradients of the lower atmosphere are so frequently at variance with the above statement in regard to the seasonal changes that it seems desirable to test it by a large number of direct observations. I have, therefore, brought together in Table 1 all the published summer and winter gradients between 3,000 and 8,000 meters elevation obtained since 1904 with sounding balloons at five different stations.

The 3,000-meter level is just above the lower turbulent region, in which to measure the temperature gradient is akin

to measuring the flow of a river by putting the float in an eddy near the shore, while the 8,000-meter level is safely below the upper inversion. It is in this region of comparatively uniform changes that seasonal effects are most clearly seen.

TABLE 1.—*Observed vertical temperature gradients between 3,000 and 8,000 meters elevation.*

Date.	Elevation.	Temperature.	$\frac{\Delta t}{100 m.}$	Date.	Elevation.	Temperature.	$\frac{\Delta t}{100 m.}$
			LINDENBERG.				
	Meters.	°C.			*Meters.*	°C.	
Aug. 3, 1905...	3,514 7,652	− 7.0 −40.0	0.798	July 5, 1906...	3,000 8,000	1.3 −34.9	0.724
Aug. 29, 1905...	3,000 8,000	− 2.4 −44.5	0.842	Aug. 2, 1906...	3,070 7,810	2.0 −36.7	0.817
Aug. 31, 1905...	3,000 8,000	− 1.0 −27.2	0.524	Sept. 6, 1906...	2,870 8,390	3.2 −28.4	0.572
Jan. 4, 1906...	3,000 8,000	− 4.8 −41.7	0.738	Feb. 7, 1907...	3,000 8,000	−14.2 −58.2	0.880
Feb. 1, 1906...	3,000 8,000	− 9.6 −42.4	0.656	July 4, 1907...	3,000 8,000	1.4 −26.6	0.560
July 4, 1906...	3,022 7,782	0.3 −35.3	0.746				
			PAVLOVSK.				
Feb. 9, 1905...	2,280 8,000	−17.8 −50.0	0.642	Feb. 1, 1906...	3,000 5,960	−22.1 −32.7	(0.358)
July 6, 1905...	3,000 8,000	0.9 −30.9	0.636	July. 5, 1906...	3,000 5,820	2.3 −11.7	(0.497)
Aug. 29, 1905...	3,000 8,000	− 4.4 −35.7	0.626	Sept. 6, 1906 ..	3,060 8,000	− 3.6 −36.3	0.662
Aug. 30, 1905..	3,000 8,000	− 4.0 −32.8	0.576	Jan. 14, 1907...	3,000 7,800	−21.0 −47.8	0.670
Jan. 4, 1906...	2,970 8,000	− 8.3 −41.6	0.662	Feb. 7, 1907...	3,000 8,000	−12.6 −49.5	0.738
Mar. 1, 1906...	3,000 8,000	−16.7 −52.5	0.716	Mar. 7, 1907...	3,000 8,020	−15.5 −44.3	0.575
			STRASSBURG.				
	Meters.	°C.			*Meters.*	°C.	
Jan. 5, 1905. .	3,000 8,000	− 4.2 −41.4	0.744	Mar. 1, 1906. .	3,000 7,000	−12.4 −38.6	0.655
Mar. 2, 1905...	3,000 8,000	−14.0 −51.3	0.746	July 4, 1906. .	3,000 7,000	2.2 −24.5	0.668
July 6, 1905...	3,000 8,000	0.1 −31.7	0.636	July 5, 1906. .	3,000 8,000	2.6 −29.6	0.642
Aug. 3, 1905...	3,000 8,000	8.2 −19.1	0.546	July 6, 1906. .	3,000 3.000	− 1.9 −30.7	0.576
Aug. 29, 1905...	3,000 8,000	− 4.7 −37.7	0.660	Aug. 2, 1906. .	3,000 8,000	8.0 −25.3	0.666
Aug. 30, 1905...	3,000 8,000	− 4.3 −36.4	0.642	Sept. 6, 1906. .	3,000 8,000	3.7 −27.9	0.603
Aug. 31, 1905...	3,000 8,000	− 2.8 −33.7	0.618	Jan. 4, 1907. .	3,000 8,000	− 5.1 −38.4	0.666
Jan. 4, 1906...	3,000 8,000	− 8.5 −43.3	0.696	Feb. 7, 1907. .	3,000 8,000	−11.4 −51.4	0.800
Feb. 1, 1906...	3,000 8,000	− 8.4 −41.2	0.656	Mar. 7, 1907 .	3,000 8,000	−13.4 −47.2	0.676
			TRAPPES.				
Jan. 5, 1905...	3,000 8,000	− 7.8 −45.6	0.756	Mar. 1, 1906. .	3,000 7,000	− 8.3 −42.4	0.852
Mar. 2, 1905...	3,000 7,000	−17.0 −51.0	0.850	July 4. 1906. .	3,000 8,000	− 0.2 −31.7	0.603
July 6, 1905...	3,000 8,000	0.6 −27.6	0.564	July 5, 1906. .	3,000 8,000	3.2 −27.8	0.602
Aug. 3, 1905...	3,000 7,800	8.7 −23.7	0.573	Aug. 2, 1906. .	3,000 8,000	11.7 −19.9	0.603
Aug. 29, 1905...	3,000 8,000	− 5.6 −42.4	0.736	Sept. 6, 1906. .	3,000 8,000	0.4 −28.5	0.578
Aug. 30, 1905...	3,000 8,000	− 1.1 −41.6	0.810	Jan. 4, 1907. .	3,000 8,000	− 3.2 −41.8	0.772
Aug. 31, 1905...	3,000 7,540	− 4.4 −37.8	0.736	Feb. 7, 1007. .	3,000 8,000	−14.6 −57.9	0.866
Jan. 4, 1906...	3,000 7,850	− 5.7 −41.4	0.736	July 4, 1907	3,000 8,000	− 5.5 −34.0	0.570
Feb. 1, 1906...	3,090 8,000	− 4.1 −33.8	0.594				
			UCCLE.				
July 5, 1906...	3,490 8,460	− 4.0 −43.5	.795	Sept. 5, 1907. .	3,492 9,050	0.8 −31.9	.588
Aug. 2, 1906...	2,900 8,240	10.1 −26.4	.683	Jan. 3, 1908. .	2,627 8,375	− 9.7 −51.1	.720
Jan. 14, 1907...	2,990 8,550	− 4.5 −40.5	.647	Feb. 6, 1908. .	3,000 8,000	− 4.0 −38.9	.698
Feb. 7, 1907...	2,970 7,740	−11.4 −46.3	.732	Mar. 5, 1908. .	3,000 7,000	−19.0 −55.7	.917
Mar. 7, 1907...	2,960 8,830	− 7.2 −47.8	.756	July 29, 1908. .	3,000 7,700	3.0 −25.2	.600
July 24, 1997 ..	3,428 8,854	2.2 −33.3	.654	July 30, 1908. .	3,000 8,000	2.3 −29.0	.626
July 25, 1907...	3,598 8,856	3.2 −31.7	.664	Sept. 3, 1908. .	3,000 8,000	−10.6 −42.1	.630

TABLE 2.—*Average vertical temperature gradients between 3,000 and 8,000 meters elevation,* $\frac{\Delta t}{100 \text{ m.}}$

Place.	Summer.	Winter.
Lindenberg	0.699	0.758
Pavlovsk	0.599 (0.625)	0.623 (0.667)
Strassburg	0.626	0.705
Trappes	0.637	0.775
Uccle	0.655	0.745
Average	0.643 (0.648)	0.721 (0.730)

The observations obtained at Uccle are copied from Ciel et Terre, the others from Veröffentlichungen der International Commission für Wissenschaftliche Luftschiffahrt.

The average gradients, exprest in change of temperature in degrees centigrade per hundred meters change in elevation, are given in Table 2. The seventy-two observations upon which they are based are not nearly enough to secure averages free from storm and other irregularities, but probably are sufficient to demonstrate the kind of change in the gradient caused by change of season. As shown by Table 2 the gradient at each of these stations was greater in winter than during the summer, the general average being about 10 to 9.

Two of the gradients found at Pavlovsk were exceptionally low, probably due to unusual local conditions. The numbers inclosed in parentheses give the averages with these exceptional gradients ruled out. The others with them included.

THE FORMATION OF HAIL.

By Dr. J. B. GIBSON. Dated Salisbury, N. C., January 5, 1909.

In the MONTHLY WEATHER REVIEW for January, 1906, 34:30, the Editor has published some observations by Doctor Gibson on the formation of hail, and the following extract from a recent letter presents a slight modification of his earlier views:

It is well known that, as a rule, hail precedes the rain. The general opinion that hailstones have a nucleus of snow I do not believe to be justified. * * * Consider a tumbler of water with all but its central portion turned into crystal ice. This is the natural process in the open air. Before solidification is entirely completed hold the central portion of the glass up at the level of the eye and shake it. A globular mass of unfrozen water and mush ice will be found in the dark central portion. Now let freezing completely solidify the contents of the glass and this central part will be a mass of snow-white striæ radiating in every direction. These streaks are as white as cotton thread. This central white core is what is seen in the hailstone, and is produced by the natural process of freezing the central portion last. I venture to assert that snow will not form at all under conditions such that sleet and hail will be generated readily and abundantly.

THE IMPORTANCE OF SYSTEMATIC OBSERVATION OF PERSISTENT METEOR TRAINS.

By C. C. TROWBRIDGE, D. Sc., Columbia University. Dated September, 1908.

[Reprinted from The Observatory, No. 402, November, 1908.]

The nature of the luminous cloud occasionally seen in the track of large meteors, known as the presistent streak or train, has long been regarded as a mystery by astronomers. Meteors which leave these long-enduring trains are few in comparison to the total number of meteors that are observed, and consequently even experienced observers are sometimes taken unprepared, and fail to record an observation with desired detail. Many trains have been seen, however, which have remained visible from ten to thirty minutes, and definite and authentic facts concerning them have been recorded in numerous cases. The late Prof. H. A. Newton, of Yale University, and Prof. E. E. Barnard, of the Yerkes Observatory, have both published some valuable observations on the drift of trains in the United States, and the late Prof. A. S. Herschel, Mr. W. F. Denning, Mr. T. W. Backhouse, and others have likewise published many important facts relating to presistent trains seen in England. Indeed, a very large part of the progress of meteoric astronomy

during the past fifty years is due to the accurate and persevering work of the meteor observers of Great Britain.

Apart from the many recorded observations, only a few brief papers relating to meteor trains have been published. Astronomers appear either to have considered the study of them out of their province, or else for various reasons they have devoted their attention to problems more truly astronomical in nature. The study of presistent meteor trains is highly important, not only because of the general problems relating to the atmosphere of the earth that are involved, but also on account of the bearing of the phenonenon on certain recent discoveries in physics.

It is the purpose of the present paper to show why it is important that every meteor train should be carefully observed and the details of each observation recorded with the utmost accuracy; and to emphasize the fact that owing to the uncertain and sporadic occurrence of meteor trains, the physicist must ever rely on the astronomer for careful and complete records on which to base his deductions. It is obviously necessary that those features of the meteor train which appear to the physicist to be most important should be specially mentioned, and therefore a portion of this paper is devoted to this purpose. Already certain of the features of meteor trains can be explained by the behavior of apparently similar phenomena which have been produced in the physical laboratory. Indeed the results of recent experiments by the writer on gas phosphorescence[1] seems to show that the self-luminous meteor train is also some form of gas phosphorescence. These laboratory experiments necessarily must be referred to in considering the present subject.

Some of the reasons why very careful observation of meteor trains are desirable are briefly as follows:

(1) The drifting motion of meteor trains, so often observed, is unquestionably due alone to atmospheric currents. The observation of these train movements is the only means by which data concerning the motions of the extreme upper regions of the earth's atmosphere can be obtained. In a recent paper over sixty train drifts have been collected, tabulated, and discust, and several facts concerning the atmosphere brought to light.[2] Many of these trains were above 50 miles altitude and recorded by the most accurate meteor observers, Denning, Herschel, Backhouse, Booth, Newton, Barnard, Twining, etc.

(2) A statistical study of trains has shown that many at least of those seen at night are self luminous. The remarkable persistent light of the meteor train is in all probability a gas phosphorescence, since in many respects it is similar to the gaseous "afterglow" which is formed in a vacuum-tube by electrical discharges. This "afterglow," which is a true phosphorescence of the gas, appears greenish yellow when formed in air or nitrogen, and the writer has observed it persist in air for as long as *nineteen minutes* after the discharge had past thru a bulb in which it was formed. The writer has also recently found by laboratory experiments the law of the rate of decay of the luminosity of this phosphorescence. The rate of fading of the light is exprest by a formula of the form

$$I = \frac{1}{(a+bt)^2},$$

from which it follows that the intensity after twenty minutes can be approximately calculated. If the meteor train is the same phenomenon as the "afterglow," or similar to it, and when the fact is taken into account that the meteor train may be half a mile or more in diameter, the long-visible persistence of the phosphorescent train is readily explained by applying the above law of decay. In fact, if the initial phosphorescence of a train is as bright as that artificially formed in the laboratory, the train should be visible for nearly one hour. In the laboratory the discharge tubes containing the glowing gas were only several centimeters in diameter, yet the glowing gas was often visible for many minutes after the electric current was cut off.

(3) The duration of air phosphorescence produced in a discharge tube has also been timed under various pressures and other conditions,[3] and the limits of its formation are found to be so definite that if the phenomenon can be proved to be the same as the meteor train, the approximate gas pressure of the atmosphere between 50 and 60 miles height can be obtained, a fact which would be of great value. The "afterglow" has a maximum duration at about 0.1 millimeter of mercury gas pressure. The ordinary limits for long duration appear to be between 0.07 and 0.3 millimeters gas pressure. This of course suggests that the pressure of the earth's atmosphere at about 55 miles altitude, where meteor trains are most persistent, may be 0.1 millimeter.

(4) The so-called expansion of the meteor train almost always observed appears to be gas diffusion. This diffusion is dependent upon the pressure and temperature of the atmosphere at the altitude where the meteor train is formed. It is possible that this diffusion feature of the train will give another means by which the pressure of the atmosphere may be measured, since the theoretical diffusive rate can be approximately calculated, and since the diffusion of the "afterglow" at various pressures can be measured with accuracy. Both the diffusion of the meteor train and of gas phosphorescence is of the order of several meters per second. The "afterglow" or gas phosphorescence diffuses thru the glass vacuum-tubes in which it is formed at this rapid rate.

(5) Meteor trains appear to diffuse more readily in the upper portions of the streak, because many drawings of streaks are conical in form, with the apex pointing downward. Such a form of the streak is to be expected because there would be more rapid diffusion as the pressure of the atmosphere diminished; hence careful drawings of trains are very important to determine if the form is in many cases actually conical, or if the effect is due to perspective only. If the forms are often conical, observations of the different diffusion rates would give atmospheric pressure gradients [at] between 50 and 60 miles altitude.

(6) Many trains have been recorded as appearing like a double line of light, which is explained on the assumption that the luminosity is greatest near the outside of the train, the train thus being tubular. This has an important bearing on the decay of phosphorescence, since the gas afterglow (air) under certain conditions appears to disappear most rapidly where it is formed. Many trains in the writer's meteor-train catalog show this dual appearance of the train.

(7) A record of the total length of track of the meteor and the length and location of the train with respect to the track is important, since it shows the limits of the atmospheric zone where the self-luminous train can be formed and persist.

(8) Careful drawings of the form of trains, either self-luminous or shining by reflected sunlight, at intervals of time after first appearance, would be of value, because frequently the sketch would be found to be a record of some facts concerning atmospheric movements; for example, a sharply-bent train usually indicates a rapid current above or below a relatively calm zone in the atmosphere.

It has been shown by Mr. Denning, Professor Barnard, and others that meteor trains visible to the naked eye for one or two minutes can be seen in the telescope sometimes for over a quarter of an hour. Thus by the use of a low-power mounted telescope, or even a pair of good field glasses, meteor trains

[1] Trowbridge, Astrophysical Journal, September, 1907, p. 95-116, figs. 1-9.

[2] Trowbridge, Monthly Weather Review, September, 1907, 35: 390-396, figs. 1-7, tables 1-5.

[3] Trowbridge, The Physical Review, 4, Oct. 1906, vol. XXIII. p. 279-306.

can often be studied to greater advantage than by the naked eye alone. The track of every bright meteor should be examined with such a telescope to determine if a faint persistent train remains. It is probable that in this way many persistent trains can be discovered which would not be observed by the naked eye. Moreover, Mr. Denning has shown that a great many meteors are visible in a telescope which are invisible to the naked eye, and he also gives instances where persistent trains of these telescopic meteors have been thus detected. It would also be of great value to use a mounted telescope having a micrometer eyepiece or some device by which the width of the trains could be measured to a fraction of a degree accurately. The same instrument would be of service in locating the position of the train and determining in an accurate manner the rate of drift. Also, since the streak-bearing meteors are fairly well known, watches at adjacent observatories near enough for a good base line could be maintained for the few nights of the year when these meteors occur, for the purpose of doubly observing the train drifts and determining the height of the trains. It is hoped that a definite plan can be formulated for the systematic observation of meteor trains in the future, because they provide the only means by which data concerning the extreme upper regions of the earth's atmosphere can be obtained.

The physicist, by the aid of laboratory experiments, may be able to work out the solution of the meteor-trains problem, but the facts of the phenomena must be observed by the astronomer. The following suggestions are made because it has been found that many records of the past which might have been very valuable have been made of little use by the omission of details in the published reports. It therefore becomes necessary to point out what facts of a meteor-train observation are most important. The facts to be recorded are placed under two headings, because the statements in regard to the meteor nucleus or hot moving body and its train of sparks must be clearly distinguishable in the records from those relating to the true train or streak which remains visible for many seconds or minutes. In many reports there has been confusion in this respect. A third heading might cover various other facts which need not be considered at the time of the observation of the train, but which nevertheless are essential for a complete record. Every one of the following points are important in the record of the observation of a meteor train if they can be noted. *A high degree of accuracy is, however, of the first importance even if it is necessary that the observation be confined to but a few features of the train.*

A. *Observations concerning the meteor nucleus.*

(1) Time of appearance of meteor nucleus and of duration of its flight.

(2) Radiant point and name of meteor (Leonid, Perseid, etc.).

(3) Color of nucleus, length of track, and length of portion of streak with respect to the entire track.

B. *Observation of the persistent train or streak.*

(4) Color of train immediately *after* disappearance of nucleus and *any change of color* of the train during the time that it is visible.

(5) Length and width of train, in degrees and minutes of arc, immediately after disappearance of nucleus, and its position in the heavens with respect to easily identified stars.

(6) Observations, at short intervals of time, of the change of dimensions of the train in degrees, accompanied by a series of the drawings, if possible, indicating the successive changes in shape of the train. *The width of the train*, or a portion of it, *at successive intervals of time*, is of the greatest importance, since it indicates *the rate of diffusion of the gaseous mass.*

(7) The displacement or drift of the train in degrees, with corresponding time. For this purpose some *bright portion of the train* should be selected *when the train is first seen.* Also the direction of the drift with *respect to the earth's surface*, and if calculations are made of the rate in miles, they should be so stated.

(8) If the intensity of light of the train is (1) uniform, (2) brightest on the outside, or (3) brightest at the center, and the time of this observation after the first appearance of the meteor.

(9) Whether the train increases in brightness, this effect appears to occur not infrequently. The observer should be careful not to mistake an increase in the dimensions of the train for an increase in intensity.

(10) Spectroscopic observations, looking for the presence and position in the spectrum of one yellow line and one or two lines in the green.

(11) How long the train is visible to the naked eye and how long visible in the telescope.

Systematic and accurate observations of persistent meteor trains will in all probability lead to results of much practical value. It is within reason to hope that light may be thrown on the following problems: (1) The cause of the apparent self-luminosity of the meteor train; (2) the height of the earth's atmosphere, by accurate measurement of telescopic trains; (3) the density of the earth's atmosphere at an altitude of 50 to 65 miles, by a direct comparison with the pressure at which gas phosphorescence can occur if the meteor train is an "after-glow;" (4) the direction and velocity of currents in the atmosphere at great altitudes; (5) the possible relation of atmospheric motion at high altitudes to barometric pressure, and some other facts which seem indicated by the statistical work done by the writer which require further data for confirmation.

TRANSFORMATIONS OF SNOW CRYSTALS.

By A. ERMAN. Dated, 1859.

The following extract, here reprinted from the London Philosophical Magazine, 1859, **17** (4th series): 410–413, presents some observations on the transformations of snow crystals, made by A. Erman during his trip around the world. They were published in his Reise um die Erde[1] and translated by him for Tyndall, who published them in the above journal. We omit the figures given in the London Philosophical Magazine.—*C. A.*

May 13, [1829?] Latitude 60° 40′, longitude 138° 57′ east from Paris, at 2580 Parisian feet (2749 English) above the sea.—I had begun immediately after noon to measure solar altitudes, when a number of light clouds began to form and then to be driven fast by the west wind. The air cooled down (from about +3° R. [38.8° F.]) to +1° R. (34.2° F.), and snow fell for sixteen minutes; then the clouds dissolved again, the evening became clear, and the cold increased in the night to −5° R. (20.8° F.). I have never seen snow in more perfect and variously formed crystals than during this short and sudden shower. Each grain fell single, and among the few which settled on the glass or the metal of my instruments, I could distinguish six different forms. Doubtless many more remained unobserved, for my attention was drawn in the meantime to a more wonderful and quite novel phenomenon. Many of the crystals began to melt the instant they touched a solid body, and some, as it seemed to me, melted while still falling thru the air; but in the next moment this was followed always by a new congelation, the grain of snow assuming, not its previous form, but another more complex. Thus, for instance, the most simple crystals which I observed to-day, consisting of six thin needles of ice, which adhered to each other like the diagonals of a regular hexagon (fig. 2*a*). When melting, each single ray of this star contracted into a thicker cylinder of water, having about half of its former length

[1] Ermann: Reise um die Erde, 1835-1849, Hist. Abth, **2**:395; or the English translation, abridged, Travels in Siberia. London, 1848. **2**:501.

(fig. 2b); but after a few moments these cylinders were seen to congeal again, and change thereby into broader plates, sharpened at their outer edges by two planes of a regular hexagonal prism. The whole crystal became thus again a hexagonal star, but with broader and shorter rays than it hadbefore.

Other crystals, which had at the beginning such flat and broad rays (fig. 2c), changed these by melting into feathered ones (fig. 3c), because on their liquefaction there remained only the middle of each plate, like an icy needle, in the water, until, the new congelation ensuing, a number of needles ran at each side out of this rib at angles of 60 degrees.

Some of the stars were feathered in the beginning, but only at the outer half of their rays. I did not see any change take place in them, nor did this happen with some other more complicated forms. Thus I observed among others a small and continuous hexagonal plate, with simple rays issuing like diagonals out of its angles; but then each adjoining pair of these rays was still connected by a couple of needles which met at an angle of 60 degrees (fig. 4).

But these complicated forms were comparatively rare; and those transformed under my eyes were so predominant, and presented a spectacle so full of motion, that at last I could hardly help comparing them with living beings. In fact it is only in the case of such that we are accustomed to witness changes so mysterious without inquiring after the forces that produce them. We got, however, a partial explanation of this phenomenon by remarking that the outer parts of the snow-crystal, which were the first to melt, borrowed their warmth of liquefaction from the parts that remained solid, and thereby cooled these below the point of congelation. The newly-formed water could then freeze again by its collecting round this cold ice, and by its offering at the same time a smaller surface[2] to the air whose temperature had melted the crystal. This water then assumed in freezing a more complicated form, because the remainder of the old crystal exerted in it a greater variety of attraction than that which occurs in a wholly liquid drop. Perhaps all complicated forms of snow [crystals] result from the simple one by melting and freezing again in this way, a process which they must then undergo during their fall thru the air; and here this hypothesis seemed somewhat confirmed by the complicated crystals being always of less diameter than the simple ones.

Additional remark (April, 1859).—I have sometimes watched the snow-crystals which fell at Berlin when the temperature of the air was a little higher than the freezing-point, but till now without seeing again the phenomenon just mentioned. We may suppose either that these observations were still too rare to present some one of those neglected and apparently trifling circumstances that are requisite for the phenomenon in question, or that this depended also on the spot where I made my first observation having been at a considerable elevation, and consequently not far from the atmospheric stratum where the snow was first formed. But then, as to the explanation of the observed metamorphosis of snow, I think it might have some connection with the equally obscure property of some chemical precipitates, which, like carbonate of lime, according to M. Ehrenberg, consist, when first consolidated, of regularly arranged solid globules, and which are then changed, "all of a sudden and quite wonderfully," to aggregates of true crystals of microscopic size. (Cf. Ehrenberg in Abhandlungen der Berliner Akademie, 1840.)

THE CRYSTALIZATION OF UNDERCOOLED WATER.

By BORIS WEINBERG. Dated St. Petersburg, July, 1908.

[Reprinted from the Physical Review, 1908, **27**:509-510.]

In order to show the undercooling of water and to allow the free development of its crystals I endeavored to introduce into the undercooled water a piece of ice put in a finely drawn out glass tube. The experiment, carried out the first time by Michael Tvanov, gave an unexpected result. When the crystallization attained the end of the tube there began to grow at this point an ice crystal having the shape of an hexagonal star and very similar to the characteristic snow crystals.

The greater the undercooling of the water the more numerous were the ramifications and the greater the velocity of crystallization. With water undercooled to a temperature between —0.3° and —1° C. I obtained small stars with few narrow ramifications, see fig. 1. Undercooling to a temperature between —1° and —3° C. gave rise to stars with such dense ramifications that they resembled hexagonal plates, see fig. 2. The plane of the stars contains the direction of the end of the tube, and therefore when this end is vertical a sufficiently large plate can divide the tube into two parts. An undercooling greater than —3° C., especially when the end of the tube is not narrow enough, produces several plates set in different azimuths, and the whole mass becomes at last a mass of differently sized crystals and water, resembling the so-called "anchor ice."

FIG. 1.

The crystals are often a conglomeration of several stars which have their planes, their principal rays, and even the ramifications of higher order parallel as in fig. 3.

If a star is broken, the pieces of it rise horizontally in the water with slight oscillations and attain the surface. This circumstance can explain the verticality of the optic axis by river and lake ice.

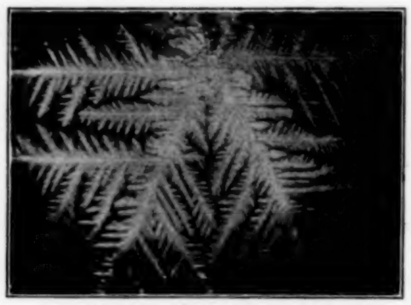

FIG. 2.

The evolution of these artificial snow crystals can be easily projected on a screen, if the vessel (a tumbler, an alembic, an evaporating dish) with undercooled water is put into another vessel with plane-parallel sides containing water at a temperature somewhat higher than the thaw temperature [dew-point?] of the surrounding air. For undercooling any water can serve, but the refrigerating mixture (finely chopped ice upon which is poured a strong solution of NaCl) must not be too cold (from —4° to —6° C.) and its level must be lower than the level of the water which is to be undercooled.

The projection is especially beautiful when the vessel is placed between crost nicols, as in figs. 1–3. A star on a

[2] Viz, the *curved* surface of a single, or of six connected drops.

dark ground grows which gradually becomes more and more bright and at last, when thick enough (the thickness is generally of the order of a tenth of a millimeter), shows the colors of chromatic polarization. One can prove that these crystals are optically uniaxial; if the tube is turned so that the plane of a star is at right angles to the rays of polarized light the image of the star disappears.

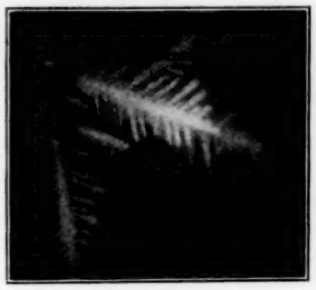

FIG. 3.

Precise measurements of these crystals will be made in winter when it will be possible to prolong their fugitive existence.

The size of the stars depends—at a sufficient undercooling, e. g., —2° C.—principally on the dimensions of the vessel with undercooled water. I often obtained single stars 8 to 12 centimeters broad.

RECENT EXTENSIONS OF THE CANADIAN METEOROLOGICAL SERVICE.

Director R. F. Stupart of the Canadian Meteorological Service in his letter of March 3, 1909, states that during the past summer he supplied barometers and a full equipment to the following stations in extreme northern Canada:

Fort McMurray,	latitude 56.40° N.,	longitude 111.25° W.
Fort Chipewyan,	latitude 58.41° N.,	longitude 111.10° W.
Hay River,	latitude 60.51° N.,	longitude 115.20° W.
Fort Simpson,	latitude 61.52° N.,	longitude 120.43° W.
Fort Norman,	latitude 64.57° N.,	longitude 125.00° W.
Fort Macpherson,	latitude 67.27° N.,	longitude 134.57° W.

where the observers will be paid for satisfactory service. This service has also just started two new stations in Newfoundland at Point au Basques and Burin. In the spring a station at Fogo and another on the Labrador coast will be put in operation, and the service then contemplates issuing storm warnings and forecasts for Newfoundland.—*C. A., jr.*

THEORIES OF THE COLOR OF THE SKY.

By EDWARD L. NICHOLS.[1]

Presidential address delivered at the New York meeting of the Physical Society, February 29, 1908.

[ABSTRACT.]

The author summarizes the various theories explanatory of the color of the sky, as follows:

1. The turbidity of the atmosphere would of itself give us a blue sky, but the ideal medium of Rayleigh would afford a distribution of intensities to which the actual sky rarely if ever corresponds.

2. Even were the atmosphere free from particles of dust, condensed water vapor or other extraneous matter it would not, according to Rayleigh's latest paper, be optically empty, to use the term employed by Tyndall, but would be blue by virtue of reflections from the molecules of the air itself.

3. If there were no other source of blueness, the color of the air according to Spring, would give us a blue sky by virtue of the selective absorption-color of various of its constituents. The objections to the adoption of this as a factor are obvious and are regarded by many writers as insuperable, but their arguments are not, in my opinion, conclusive.

4. Reflections from surfaces in a troubled atmosphere as pointed out by Hagenbach, would give us light from the sky increasing in intensity relatively to sunlight in proportion to the square of the wave-length. This is quite sufficient to account for the average blueness of the sky, but not for the intenser blueness frequently observed. It cannot therefore be regarded as the sole or most important factor.

5. Fluorescence as a factor of blueness of the sky cannot be definitely considered at the present time for lack of experimental data concerning it.

6. As regards the subjective or physiological factor it may be said that were there no other cause the sky would undoubtedly appear blue; for we still see it blue where measurements with the spectrophometer indicate a composition relatively much weaker in the shorter wave-lengths of the spectrum than the *average* composition of sunlight. In the present paper I shall, however, consider only the objective factors.

The problem of the color of the sky is stated as resolving itself into a determination of the relative importance of these various factors, the existence of all of which, with the possible exception of fluorescence, may be regarded as experimentally established. The phenomena of aerial polarization are believed to indicate beyond any doubt that the turbidity of the air is one source of the blueness of the sky. But while Rayleigh's masterly theoretical work—which calls for relative intensities of the reflected ray as compared to the incident ray varying inversely as the fourth power of the wave-lengths—has found complete verification in the studies of artificial media, spectrophotometric measurements of the sky itself have led to widely varying results. Thus, Zettwuch, who made many measurements at Rome, calls especial attention to the variability of the ratios. Crova, at Montpellier, whose measurements extend only between wave-lengths 0.635μ and 0.510μ, found the exponent to vary from 1.61 to 6.44. The author therefore seeks other sources than turbidity for the blue color of the sky.

Numerous measurements of the spectrum of the sky made by the author with a portable spectrophotometer show, in general, far greater relative intensities of the longer wave-lengths than one would expect from the theory of Rayleigh, which is based upon the assumption of an ideal turbid medium in which the diameters of all the particles in the medium are small as compared with the wave-length of light. The following are given as obvious causes of the discrepancies between theoretical and observed ratios of intensities:

(*a*) The presence of larger reflecting particles in the atmosphere, sometimes invisible and sometimes forming masses of mist or cloud.

(*b*) Absorption by transmission through the turbid medium itself.

(*c*) Illumination of the atmosphere by light reflected from the surface of the earth.

Curves of ratios based on observations taken at dawn and in the twilight after sunset, show but little variation from day to day in fair weather, and approximate closely to the ratio curves called for by Rayleigh's equations. During the day, while the sky-light taken as a whole increases greatly in intensity as the sun approaches the zenith, the actual intensities of the blue and the violet are much less affected than are the longer wave-lengths. When the moisture of the atmosphere condenses into cloud forms [cumulus] in the middle of the day, there is a marked diminution in the relative intensity of the sky-light at the violet end of the spectrum.

Evidence is found of the modification to a measurable extent of the character of the light of the sky by reflection from foliage, from clouds, and from the ground.

Reference is made to Pernter's study of the polarization of light emitted at right angles to the incident beam by emulsions of different colors. In general, the whiter the emulsion the less the polarization, which is also true of the sky. For a blue emulsion the green ray showed the greatest polarization, the blue next, and then the red. For a white emulsion the red ray showed the more polarization, there being a diminution toward the violet. Pernter found this also to be true of blue and white skies. The author found that the polarization of sky-light was sometimes greatest in the red, sometimes in the violet, sometimes in an intermediate color, and sometimes uniform for all wave-lengths, probably depending upon the size of the particles present in the atmosphere.

[1]Physical Review, Vol. XXVI, p. 497.

As stated above, Rayleigh's theory requires that the ratio of the intensity of the reflected ray to that of the incident ray shall vary as the fourth power of the wave-length, while Crova's measurements gave exponents varying between 1.61 and 6.44. From this fact, and further, since the author's observations often showed greater proportional intensity for the violet as compared with the red than for intermediate colors, he considers it probable that the blue color of the air itself and a blue or violet due to the fluorescence of ozone or other components of the atmosphere are to be regarded as possible factors in the production of the color of the sky, altho the data upon this subject must be considered incomplete and inexact.

The following is the author's summary:

1. That while there is good reason for regarding the sky as a turbid medium, the experimental study of the spectrum of sky-light affords evidence of a distribution of intensities which cannot be altogether accounted for by the assumption of an atmosphere conforming to Rayleigh's formula nor of a turbid medium containing coarser particles.

2. That the illumination of the atmosphere by selectively reflected light from the surface of the earth and from cloud masses and mist modifies the character of the light from the sky to an extent which, while perhaps not readily discernible with the unaided eye, is definite and unmistakable when the sky is studied with the spectrophotometer.

3. That the deviation of the observed distribution of intensities recorded by several investigators indicates a blue absorption color of the air or, since the preponderance in the violet appears to be variable in amount, the existence of fluorescence of some unstable factor of the atmosphere, such as ozone, or both.

The results of observations on the percentage of polarization of skylight at the point of maximum polarization made by me in Washington at the Weather Bureau may be summarized as follows:

1. Since the observations were made on cloudless days, the sources of illumination of the sky are considered to be (*a*) the scattering of light by particles in the atmosphere whose diameters are small as compared with the wave-length of light, (*b*) the scattering of light by relatively large particles, and (*c*) the reflection of both sunlight and sky-light from the surface of the earth.

2. When the ground is covered with snow there is a marked decrease in the percentage of polarization, due to increased reflection from the surface of the earth.

3. There is a diurnal variation in the measured percentage of polarization, the minimum ocurring at noon, with a gradual increase as the sun approaches the horizon, and a marked increase during the first few minutes of twilight following sunset, which may be attributed to relatively less reflection from the ground than from the particles in the atmosphere as the zenith distance of the sun increases.

4. The percentage of polarization decreases as the general atmospheric absorption increases, but apparently not by a simple law.

These results, which will be published in full in Vol. 2, Part 2, Bulletin of the Mount Weather Observatory, appear to be in accord with the summary given by Nichols.—*H. H. K.*

DUSTSTORMS IN TEXAS.

A correspondent calls attention to the fact that it is commonly believed in southern Texas, that whenever duststorms occur with high winds moving eastward across the plains, then the regions to the northward in Oklahoma and east Texas suffer from tornadoes. The following reply to this letter has been sent by the Acting Chief and sufficiently explains the reasons for this:

You will find by reference to daily weather maps issued by the Weather Bureau that the duststorms of western Texas occur in the south quadrants of well-marked low barometer areas, or general storms, the centers of which are moving eastward over the States to the northward. On January 27 and 28, the dates to which you refer, the center of a severe storm moved from Colorado eastward over Kansas. The westerly gales experienced in western and northern Texas obeyed the law of the cyclonic circulation of winds. As air moisture is considered essential to the development of tornadoes, the dry air of the plains region does not present the tornadic elements that are found in more eastern districts. To this fact may be ascribed the greater frequency of local storms in eastern Texas and Oklahoma as compared to western portions of Texas.

It is proper to add to the above that, from the beginning of forecasting work, it has always been recognized that tornadoes occur in the southern quadrant of an area of low pressure, so that the forecast that "conditions are favorable for severe local storms" has frequently been published. Thunderstorms also occur most frequently in this quadrant, and so also the hot winds that injure the crops in the region between Texas and Iowa. It is scarcely proper to say that the duststorms of Texas literally change into tornadoes; but it is more proper to say that the conditions favoring the formation of duststorms in Texas will, as they advance eastward, favor the formation of tornadoes in the moister air farther east.—*C. A.*

THE AURORA POLARIS.

In a previous number of the MONTHLY WEATHER REVIEW[1] we have given a brief synopsis of the researches of Prof. Kristian Birkeland and Carl Störmer on the newest views with regard to the nature of the aurora borealis. We are now glad to announce the publication of the first part of two volumes by Birkeland, entitled "The Norwegian Aurora Polaris Expedition, 1902–3, Vol. I. On the cause of Magnetic Storms, and the Origin of Terrestrial Magnetism. First Section."[2]

Being in English we doubt not that this volume will be read by many of the readers of the MONTHLY WEATHER REVIEW, and we can not resist the temptation to reproduce the following clear statement by the author, of the present state of his investigations.—*C. A.*

SUMMARY OF CONTENTS.

By Prof. K. BIRKELAND.

The knowledge gained, since 1896, in radio-activity has favored the view to which I gave expression in that year, namely, that magnetic disturbances on the earth, and aurora borealis, are due to corpuscular rays emitted by the sun.

During the period from 1896 to 1903, I carried out, in all, three expeditions to the polar regions for the purpose of procuring material that might further confirm this opinion. I have, moreover, during the last ten years, by the aid of numerous experimental investigations, endeavored to form a theory that should explain the origin of these phenomena. It is the results of these investigations that are recorded in this work, the first volume of which treats of terrestrial magnetic phenomena and earth currents, this section forming the first two-thirds of the volume. The second volume will treat of auroras and some results of meteorological observations made at our stations.

The leading principle that I have followed in this work has been to endeavor always to interpret the results of the worked-up terrestrial-magnetic observations, and the observations of auroras, upon the basis of my above-mentioned theory.

Thus, the magnetic storms, for instance, have been studied in such a manner that on the one hand we have formed from our observation-material a field of force which gives as complete a representation as possible of the perturbing forces ex-

[1] Monthly Weather Review, May, 1908, **36**:129–131.

[2] This "First Section" is a Royal 4to., 315 pages, 139 figures, and 21 plates.

isting on the earth at the times under consideration. On the other hand, by experimental investigations with a little magnetic terrella in a large discharge-tube, and by mathematical analysis, we have endeavored to prove that a current of electric corpuscles from the sun would give rise to [corpuscular] precipitation upon the earth, the magnetic effect of which agrees well with the magnetic field of force that was found by the observations on the earth.

Altho our observation-material of magnetic storms was, I may safely say, the largest that has ever been dealt with at one time, it was deficient in certain points, as might well be expected.

We generally had at our disposal in 1902–3, magnetic registerings from twenty-five observatories scattered all over the world, among them being our four Norwegian stations on Iceland, Spitsbergen, Nova Zembla, and in Finmark.

We have, moreover, treated separately certain well-marked magnetic storms in 1882–83, from the observations in the reports of the international polar expeditions.

In addition to the deficiencies in our observation-material, there are also defects in the experimental and mathematical investigations; but, notwithstanding all this, the results are so satisfactory that I can hardly be mistaken in my belief that we are on the right road.

Besides making clear the origin of important terrestrial phenomena, the investigations give promise of the possibility of drawing, from the energy of the corpuscular precipitation on the earth, well-founded conclusions regarding the conditions on the sun.

The disintegration theory, which has proved of the greatest value in the explanation of the radio-active phenomena, may possibly also afford sufficient explanation as to the origin of the sun's heat. The energy of the corpuscular precipitation that takes place in the polar regions during magnetic storms seems, indeed, to indicate a disintegration process in the sun of such magnitude, that it may possibly clear up this most important question in solar physics.

Future researches in the paths here entered upon, which I believe will lead to the solution of some of the most attractive scientific problems of our age, e. g., the origin of terrestrial magnetism, and the origin of the sun's heat, may be carried out upon a far wider basis than I have been able to employ without making the expenses connected therewith too great a deterrent.

In 1902–3 I had the great good fortune to have twenty-five observatories with me; but on a future occasion it will be necessary to have double the number.

We should then have to send out small expeditions with, say, ten stations suitably distributed about each of the magnetic poles, and make sure of getting magnetic registerings for the same period from all the observatories in the world.

As the position of the stations, within certain limits, may be chosen with tolerable freedom, the end would be best attained by accompanying whalers, or, as I once had to do, equipping such vessels one's self for certain places.

The mathematical investigations which, together with my experiments, are intended to make clear the movement of electric corpuscles from the sun to the earth, have been carried out with a perseverance and ingenuity worthy of all admiration by my friend Professor Störmer, who will publish the complete results of his investigations in a special part of the present work. These results, however, will be known to some extent from the papers he has already published.

The present section treats of a series of magnetic perturbations from the material from 1902 and 1903. For each separate perturbation, the magnetograms from the various observatories are arranged one after another in plates, so that the course of the perturbation can be followed from station to station.

The character of the curves in low latitudes is generally quiet, without sharp serrations. A slow variation is found in the conditions from place to place, and the deflections in the curves take place almost simultaneously over large portions of the globe.

At the polar stations, on the contrary, the curves are of an exceedingly disturbed character and very jagged, and show very great variation from place to place in the conditions during powerful storms. At these stations the perturbing forces are as a rule from ten to twenty times more powerful than they are even 20° farther south. The great deflections may frequently be followed from place to place, but in this region they do not always occur simultaneously; even at closely adjacent stations a distinct phase-displacement in these deflections is continually to be found. It would thus appear that in lower latitudes the current-systems that were in operation must be comparatively distant; whereas in the north they come into the immediate vicinity of the stations, thereby giving a more local character to the perturbations there. The movement of the systems can be followed by the phase-displacement in the deflections.

The simplest storms are studied first. They are called *elementary* storms, and are divided into five classes, namely, the positive and negative polar, the positive and negative equatorial, and the cyclo median storms.

In the next place it is shown that the ordinary complex magnetic storms may be regarded as composed of various kinds of elementary storms. The distribution of force on the earth during the above-mentioned storms is illustrated on charts by "current-arrows" whose length is proportional to the magnitude of the horizontal component of the perturbing force, and which give the direction of a horizontal electric current above each place, such as would there have produced the same magnetic effect as that actually found.

These "current-arrows," however, are no indication of the existence of such currents everywhere; they are only employed for the purpose of giving a clear general idea of the field of force in the perturbations, independent of all hypothesis.

Two of the most typical elementary fields are here reproduced (omitted). One represents the typical field of a negative polar elementary storm, the other the field in a positive equatorial storm. The first field can be explained, very simply and naturally, as the effect of corpuscular currents moving in toward the earth in the arctic regions—in this case in the auroral zone in the district surrounding Iceland—after which they turn round in an easterly direction (assuming the rays to be negative), and once more disappear into space. A current-system such as this will have approximately the same effect as a linear galvanic current consisting of two vertical current-portions connected by a horizontal portion; and it is shown that even a quantitative harmony may be attained between the field formed by such a current and the polar elementary fields that have been found. When a current-system such as this moves away, the surrounding field, we must assume, will move in the same direction. This moving of the fields is continually found in low latitudes; and in cases in which the motion of the polar system can at the same time be followed in the manner previously indicated, it is proved that they agree most exactly with one another.

The second field is explained naturally by the existence of current-systems that are formed outside the earth, more or less in the plane of the magnetic equator. The changes in the positive equatorial field are apparent in the curves, from characteristic serrations found simultaneously at all stations.

Finally, the above five types of elementary storms have proved sufficient, as regards the perturbations here described, to account for all the fields that have been formed, even during the most complex storms.

In the terrella-experiments, conditions were found that seem to confirm the correctness of this view of the cause of the magnetic perturbations; and to some extent the harmony between the results of the observations and the experiments is striking. The results of the mathematical investigations also give powerful support to this view. In connection with the polar elementary types, for instance, it may be stated that a drawing-in of rays takes place just in a zone answering to the auroral zone; and here the rays descend more or less vertically upon the terrella, and then glance past it as they turn and once more disappear into space. Further, as to the equatoral types a luminous ring is formed under certain conditions in the experiments, this ring consisting of rays that move round the terrella in the plane of its magnetic equator; and there are also found systems of rays that turn round before reaching the terrella, in just such a manner that its effect would correspond to the positive equatorial field.

Two figures representing terrella-experiments are reproduced. One is a series of eight photographs, representing an experiment in which photographs were taken from eight different points of view. The position of the terrella answers to the winter solistice and to 6 a. m. at the magnetic north pole. The photographs have been taken in such a manner as to show successively the afternoon side, the night side, and the morning side of the terrella, the cathode in the discharge-tube being supposed to represent the sun. It will be seen how rings, or rather spirals of light are formed round the magnetic poles of the terrella, and how the rays descend in zones that evidently answer to the auroral zones on the earth.

The second figure shows how the rays move in space round the terrella, and how they are drawn in more or less vertically and concentrated in the polar zones.

Finally, it is shown how the polar systems to some extent follow the sun in its diurnal motion, and how this circumstance varies when the height of the sun above the magnetic equator alters greatly. The most powerful negative polar storms originate, as a rule, on the night side of the earth, the positive polar storms generally on the afternoon side.

A STUDY OF OVERCAST SKIES.

By Prof. E. L. Nichols, Cornell University. Dated June, 1908.

[Reprinted from Physical Review, 1908, 28: 122-131.]

In two recent communications I have described the results of certain measurements of the visible spectrum of the light from the sky[1] and have made comparisons between the spectrum of daylight and that of various artificial sources of illumination.[2] In the present paper the spectrum of the light of overcast skies is more particularly considered in its relations to the spectra obtained from the cloudless sky and from skies in intermediate stages.

As in the measurements already described the instrument used was a spectrophotometer of the Lummer-Brodhun type so arranged that one collimator pointed to the zenith while the other, which was horizontal, received the light from a comparison source of nearly constant intensity and composition. This comparison source was an acetylene flame. Measurements were made thruout the visible spectrum from the extreme red at 0.74 μ to the extreme violet at 0.38 μ, thus including in the observations two regions lying close to the boundaries of the spectrum which had hitherto been comparatively neglected. The results obtained, as in the previous papers just referred to, are presented in the form of curves in which abscissas are wave-lengths and ordinates give the brightness of the spectrum of skylight in terms of the brightness of the corresponding region in the spectrum of the acetylene flame. The scale adopted is entirely arbitrary. The brightness of the comparison spectrum was adjusted to a convenient intensity by the interposition of a diaphragm in front of the flame and of a milk glass screen of neutral tint, the nonselective character of the transmitting power of which had been ascertained by careful observation. Altho many studies of the quality of the light from clear skies have been made, generally for the purpose of testing Rayleigh's theory, but little attention has been given to the light of clouded skies. So far as I am aware, indeed, the only definite spectrophotometric data are those published by Crova in the course of his extended and sytematic observations on the skies at Montpellier in France.[3]

The results to be described in this paper were made during a vacation journey in Europe in 1907.

Measurements of the spectrum of the light from the zenith taken at times when the sky was completely overcast, gave curves notable for their simplicity and for their similarity to one another. The type of these curves is sufficiently represented in fig. 1 where the curve V is for an overcast sky studied in Vienna in June, 1907, and Z represents the character of the light obtained from a similar sky measured at Zell am See, Austria, in July of that year. The former curve was taken just before noon on a rather bright but completely cloudy day, the latter about 6 p. m. when the sky was heavily overcast and threatening rain. While these two skies differ in brightness approximately in the ratio of one to two they indicate remarkable similarity as to the composition of the light coming from the clouds.

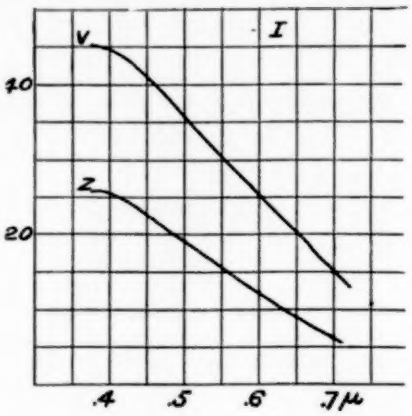

FIG. 1.

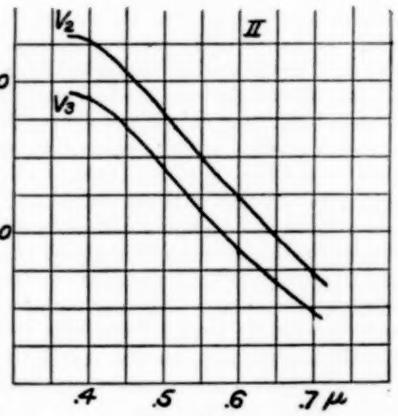

FIG. 2.

It was noted by Crova in the course of his investigation that overcast skies differ but little in composition from many cloudless skies. This observation is verified by a comparison of the

[1] Nichols, Phys. Rev., Vol. XXVI., p. 497. [See above p. 15.]

[2] Nichols, Transactions of the Illuminating Engineering Society, Vol. III., p. 301.

[3] Crova, Annales de Chimie et de Physique (6), XX., p. 480.

curves in fig. 1 with those in fig. 2, which are from measurements made at Vienna on a morning of a cloudless June day. It will be noted that curve V_2, fig. 2, is almost identical with curve V, fig. 1, and that V_3 differs from these but slightly. All of these curves show the same characteristic, namely, a slight droop in the extreme violet. That the light from a cloud in shadow is ever identical in quality with that from blue skies is, I believe, contrary to the common impression; yet it is frequently difficult to tell whether a portion of the sky toward which one is looking is clear or clouded unless one can detect the cloud structure.

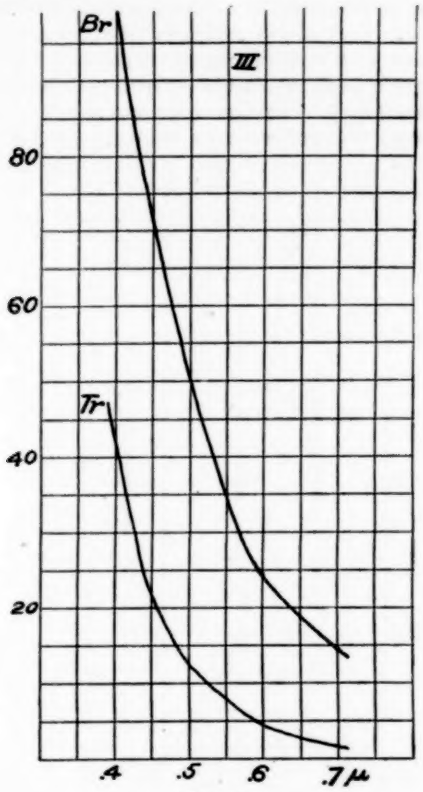

FIG. 3.

While the spectrum of overcast skies is almost identical with that of certain cloudless skies the similarity does not extend by any means to all cases. The intensely blue skies observed in fine weather in regions where the atmosphere is comparatively free from smoke and dust are of quite a different type. Measurements under such conditions give curves of which those in fig. 3 are good examples. The curve *Br* is from measurements made at Brienz, Switzerland, about 8 a. m. on a cloudless morning in August, 1907, while the curve *Tr* was obtained at Trafoi, Tyrol, before sunrise in July of that year. In these curves the relative brightness in the violet as compared with the red is several times as great as in the curves for overcast sky or in the curves for clear sky exhibition in fig. 2. There is moreover no approach to a maximum at the violet end of the spectrum and the yellow and green are relatively very weak so that the curves are strongly concave. Between these extreme types there exist numerous intermediate stages of the atmosphere which depend on the amount of condensed vapor which may be present. On a misty day, for example, when the sun is barely visible another and destinctive type of curve is obtained. Examples of this form are given in fig. 4, the curves in which were taken at Zell am See on a misty day during which clouds were continually gathering and disappearing. Curve *a* was taken at 2:30 p. m. at which time no definite cloud forms were visible but the sky was full of white mist. At 2:45 p. m. the mist cleared and the sky was blue and very bright. Curve *b* represents this condition and it is interesting to compare this curve with those in fig. 2. The intensities are nearly the same as in V_2. The curve *b* is intermediate in type between V_2 and the curves in fig 3 but much closer to V_2 in character. At 3:15 p. m. mist again filled the sky and curve *c* was obtained, the type of which corresponds in all respects with curve *a*. The intensities are the same thruout excepting in the extreme violet where measurements are at best more or less uncertain and both curves have the same characteristic maximum in the blue at 0.42 μ. This maximum is represented in reduced form in the slight drop in the curves from the overcast sky, fig. 1, and is entirely absent in those obtained from cloudless skies of the type depicted in fig. 3.

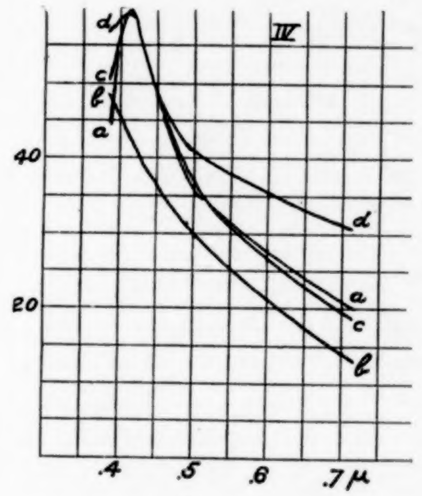

FIG. 4.

At times during the day in question the mists gathered into great masses of sunlit cumulus with patches of clear sky between. At a time when such a cloud mass filled the zenith curve *d* was obtained. In this curve the brightness of the extreme red of the spectrum at 0.7 μ is more than twice that of the spectrum of the clear sky shown in curve *b*. The intensity in the blue at 0.42 μ is the same as in curves *a* and *c* but the peculiar maximum at this region is somewhat less marked.

This maximum in the blue, which is found in all spectrum curves for misty skies which I have observed, appears regularly as the day advances in the mountainous regions of Switzerland during fine summer weather when there is a gradual formation of mist in the upper atmosphere gathering into cloud masses with a tendency toward thundershowers in the afternoon. The change in the curve occurs before the presence of mist is easily observable to the eye. The maximum is commonly well established before noon and frequently persists until toward sunset.

The gradual growth and disappearance of this characteristic may be observed whenever observations are made at intervals thruout the day under weather conditions such as I have described. Fig. 5 shows results obtained at the top of the Brienzer Rothhorn in August, 1907. The curve taken at 10:10 a. m. shows no trace of the maximum in the blue. At 11 a. m. the intensities in the blue and violet had rapidly increased and the approach to a maximum in this region began to manifest itself. At 3:30 p. m. the maximum was well marked; at 4:20 p. m. it had again almost disappeared, the type of curve being almost identical with that obtained at 11 a. m. A much more complete series of observations showing these gradual changes of form during the day was obtained at Sterzing on July 17. Measurements were begun before direct sunlight reached the valley and were continued until after sunset.

The general character of the results are shown in fig. 6, in which the curves drawn in full line are from measurements taken before noon, while the dotted curves give data obtained in the afternoon. It will be noticed that the curves at 5:20 and 7 a. m. are of the usual early morning type and similar to those of fig. 3. At 10:20 a. m., however, the maximum in the blue had developed and it persisted until late in the day. The curves at 1:30 and 5:50 p. m. show the continuance of this feature, but at 6:45 p. m. it had nearly disappeared, and at 7:20 p. m. was entirely gone. The curve at that hour had returned almost exactly to the form obtained before sunrise.

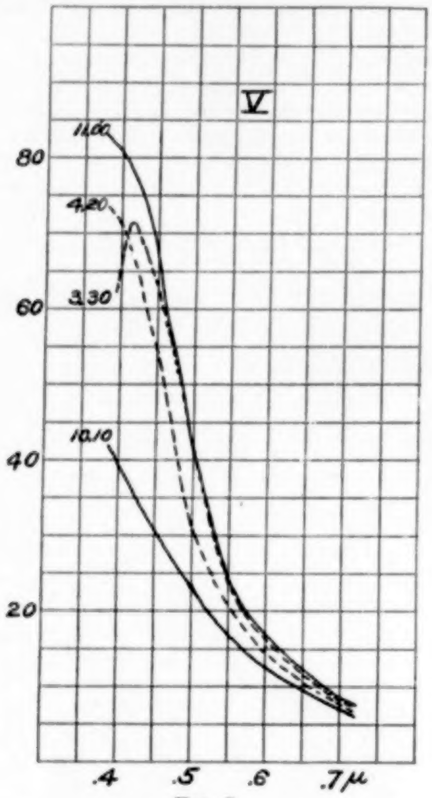

FIG. 5.

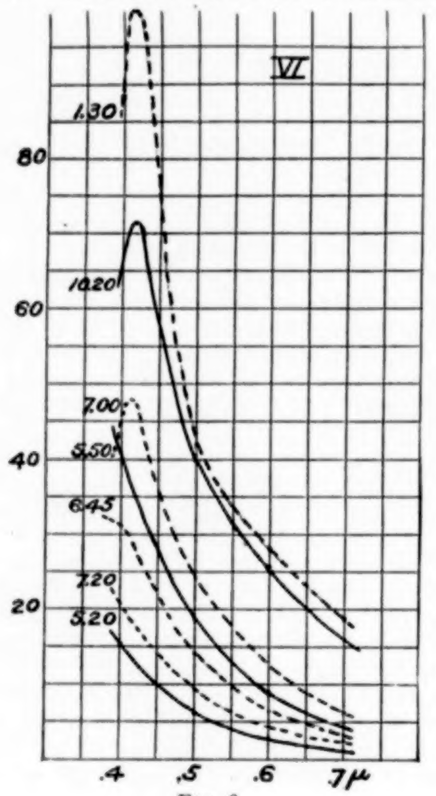

FIG. 6.

The maximum in the blue seems to occur in its most pronounced form at high altitudes. The best examples of it which I obtained were observed at Samaden in the upper Engadine, and on the upper ice field of the Rhone Glacier.

In curve *S*, fig. 7, which represents the readings taken at Samaden about 9 o'clock on a morning in July, when the sky appeared quite cloudless, the maximum is developed to an unusual degree. It will be noted that the spectrum of the light from the sky was relatively no brighter, compared with that of the acetylene flame, in the extreme violet at 0.38 μ than in the green at 0.50 μ. In the intervening region, however, the ordinates rise to double these values.

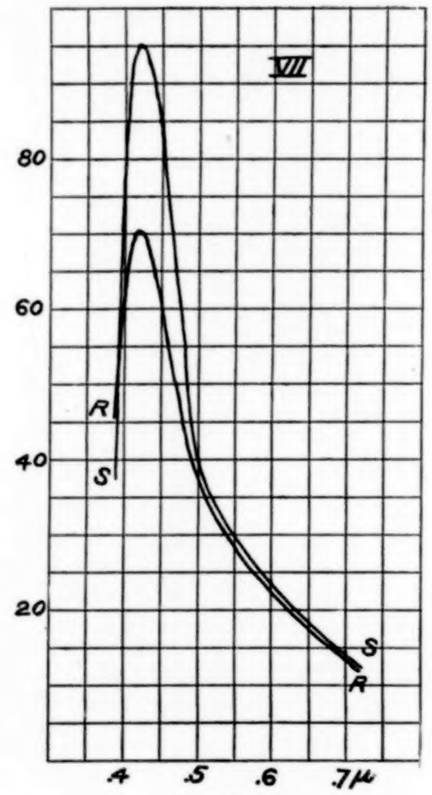

FIG. 7.

Curve *R* in fig. 7 is from measurements made on the ice field of the Rhone Glacier at a point above the ice fall near which crossing is usually made from the Belvidere to the Naegeli Graetli. It was a bright morning but mists were continually forming on the surrounding peaks and melting away so as to leave the sky overhead apparently clear. It will be noted that the intensities of the spectrum thruout the region lying between 0.5 μ and 0.7 μ are almost identical with those obtained at Samaden. The variations lie almost entirely in the blue and violet of the spectrum. Altho in these regions the curves do not coincide, the maximum at 0.42 μ appears in both.

Whether this highly variable band in the blue is an emission band superimposed upon the spectrum of a sky greatly diluted and whitened by the sunlight reflected from particles of condensed vapor, in which case it might be ascribed to the fluorescence of some variable component of the upper atmosphere, possibly ozone, as suggested by Hartley; or whether it is wholly due to selective absorption in the ultraviolet on one side and in the green on the other, as seems much more prob-

able, can not be definitely determined from existing data. In any event, it is a phenomenon absent from the clearest skies and one which is rapidly masked by the presence of considerable thicknesses of cloud materials. Whatever be its nature, it indicates an occasional departure from the distribution of intensities which characterizes the perfect sky of Rayleigh, of a sort which demands further investigation.

It will be seen from the foregoing that there are between the typical curves for the unclouded sky as exhibited in fig. 3 and the curves for completely overcast sky (fig. 1), a number of intermediate forms of considerable complexity. The presence of condensed vapor has the effect of increasing the intensity of the longer wave-lengths of the spectrum so that the ordinates of the curves are raised thruout the red, yellow, and green. At the same time the maximum in the blue is developed and the spectrum of light from the sky shows the phenomenon of selective reflection to a remarkable degree. Light from sun-illumined cloud masses exhibits the further modifications shown in curve *d* of fig. 4, in which the intensities in the red, yellow, and green reach their highest values. The maximum in the blue is in this case still noticeable, altho by no means so marked as in the case of light from a clear sky in the presence of incipient mist.

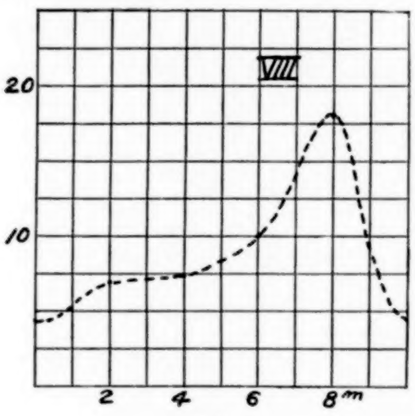

FIG. 8.

That the brightness of the sky increases with the gathering of cloud masses, up to the point where sunlight is completely shut out and the sky becomes thickly overcast, is clearly shown by means of the results graphically recorded in fig. 8. The readings from which this curve was plotted were all made from a single wave-length in the red end of the spectrum. The observations were taken during the rapid gathering of clouds upon a showery day, the initial condition being that of a blue sky with no visible mist. Measurements were made as rapidly as possible during the interval of ten minutes, at the end of which the sky was completely and heavily overcast. The curve which has time as abscissas counting from the first observation and intensities of the wave-lengths in question (0.7 μ), in terms of that of the acetylene flame as ordinates, rises to a well-marked maximum after eight minutes and then falls to a value, after ten minutes, almost identical with the value of the initial reading. The maximum corresponded as nearly as could be observed to the sudden exclusion of direct sunlight from the masses of cloud under observation, and the curve seems to indicate that up to the point where this occurred brightness increased rapidly as the mist gathered. Observations by Basquin[4] and others upon the illumination received from the sky under different conditions are quite in accord with the indications given in this curve. The brightest sky corresponds to a cloudy rather than a clear condition of the heavens, but after a certain density of the cloud masses has been attained the illumination falls off in consequence of the exclusion of direct sunlight from the visible surfaces of the clouds.

[4] Basquin, Illuminating Engineer (N. Y.), Vol. I, p. 829.

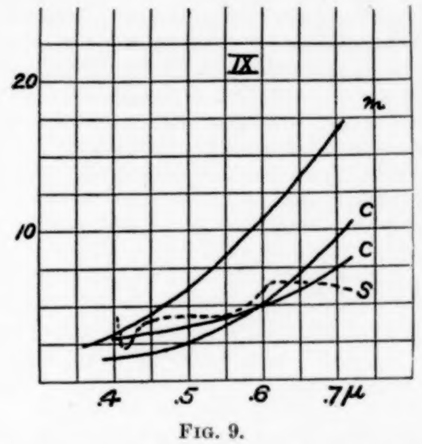

FIG. 9.

In the beginning of this paper I spoke of the curves obtained from overcast skies as being of a simple character, by which is meant that there is less evidence of selective reflection than is the case from the open sky. The distribution of intensities is such as to indicate a composition of light closely related to that of radiation from the carbon in the comparison flame, altho of course of very much higher temperature. Nearly all measurements of light from unclouded skies, particularly at times when the surface of the earth as well as the upper air are in sunlight, show on the other hand more or less well defined selectivity. A comparison of such curves with a curve for light from the sky taken upon a clear morning before sunrise—what I have called the *typical dawn curve* in the first of my previous papers already cited—shows a more or less complicated relationship like that represented in the curve *s* in fig. 9. I have discussed the nature of these ratio curves in the paper in question. When, however, we plot similar curves for the ratios of overcast or mist-filled skies to the typical dawn curve, in cases where the fog is of sufficient density to prevent the direct illumination of the surface of the ground, we get curves of the form *c* and *m* in fig. 9, which are quite free from the irregularities presented by the curve *s*. This would seem to indicate that the selectivity of ordinary skylight is due on the one hand to light reflected from the surface of the ground to the atmosphere, and on the other to selective reflection which takes place in the upper layers of the atmosphere and which is cut out by the intervention of a layer of mist or cloud so that the light from overcast skies is more directly related to sunlight, altho modified as to the distribution of intensities, than is the light commonly observed in the case of unclouded skies.

RAIN WITH LOW TEMPERATURE.

By A. LAWRENCE ROTCH. Dated Blue Hill Meteorological Observatory, January 18, 1909

[Reprinted at author's request from Boston Transcript of January 20, 1909.]

Many persons have been puzzled by observing, in the last two storms, the snow turn to rain while the temperature remained considerably below the freezing point.

The explanation is furnished by the data from kite flights which were made last week at Blue Hill in cooperation with the international series of ascensions of kites and balloons. Kites, carrying recording instruments, were flown on alternate days and entered a warm stratum, whose elevation varied from about 800 feet on the 11th to 3,500 feet on the 15th. Ordinarily, the temperature of these heights is from 3° to 10° lower than at the earth's surface, but during the past week it was actually some 10° warmer than below. Consequently, as

the storm center approached and caused a general warming-up of the air column, altho the temperature at the ground might not exceed 25°, yet in the cloud at the same time it would be 35°, giving precipitation in the form of rain.

While these inversions of temperature, as they are called, commonly occur at some height in the atmosphere, yet it is rare that an inversion of such magnitude persists so long as did the one last week. On the afternoon of the 15th the approaching cold wave was pushing in beneath the warm stratum, since the cold does not descend from the upper regions as was formerly supposed.

GREAT INVERSIONS OF TEMPERATURE.

By Prof. A. J. HENRY. Dated Mount Weather, Va., January 28, 1909.

Great inversions of temperature at Mount Weather are more frequently found in the rear than in front of cyclones and therefore are not attended by precipitation.

From the 1st to the 20th of the month of January, 1909, an inversion of temperature at one altitude or another was recorded on every day that a flight was made. On the 15th, the day mentioned by Professor Rotch in the note above printed, three inversions were recorded at Mount Weather, as follows:

At the ground (526 meters), 7.2°C.; at 690 meters, 9.8°C.; difference, +2.6° C. in 164 meters.

At 1,906 meters, 2.3°C.; at 2,109 meters, 5.7° C.; difference, +3.4°C. in 203 meters.

At 2,972 meters, 0.1°C.; at 3,031[1] meters, 0.8°C.; difference, +0.7°C. in 59 meters.

The first of these inversions was due to ground fog, the upper limit of which had risen to 1,145 meters with a temperature of 8.3°C., when the kite descended later in the day. The second inversion was due to the passage of the kites thru a cloud layer. The cause of the third inversion is not known.

Cases have arisen in which the forecaster, by reason of a knowledge of upper air temperatures, has been able to make a prediction of rain (or snow as the case may be), when the surface conditions pointed to the opposite conclusion.

A very striking inversion of temperature occurred on January 9, 1909, when all the conditions were favorable for precipitation; only a little, however, occurred. I quote the observations in full, humidity being lacking.

KITE OBSERVATIONS JANUARY 9, 1909.

	Temperature at the kite. °C.	°F.	Wind direction at the kite.
At the ground (526 meters)	—7.2	19.0	southeast.
At 750 meters	—6.3	20.7	south.
At 1,009 meters	—4.6	23.7	south-southwest.
At 1,250 meters	+1.4	34.5	south-southwest.
At 1,500 meters	6.9	44.4	south-southwest.
At 1,750 meters	9.0	48.2	south-southwest.
At 2,000 meters	7.6	45.7	south-southwest.
At 2,250 meters	5.5	41.9	south-southweat.
At 2,500 meters	3.4	38.1	south-southwest.
At 2,750 meters	1.3	34.3	southwest.

These figures show that the cold surface air extended about 500 meters above the surface and that there was a warm stratum of air moving from the south-southwest over it. The depth of this warm layer was approximately 1,750 meters (5,741 feet). Its under surface where it glided over the cold surface air was only a few degrees warmer than the next underlying stratum of air, but at its middle portion the temperature was 16.2° C. (29.2° F.), higher than at the surface of the ground. The sky was cloudy when the kites were launched, the lower level of clouds being about 900 meters above the station. At 9:15 a. m. a few snow flurries were observed as also at 12:30 p. m. after the kites had been landed.

Evidently the snow was the result of cooling by mixture along the rather indefinite boundary between the two layers of air. The upper warm current flowed in a direction parallel to the general trend of the Blue Ridge Mountains and consequently since the general level of the range changes but little, there was no opportunity for cooling by adiabatic expansion as would be the case in a current flowing at right angles to a mountain range. The air of the surface layer was saturated with moisture while that of the warmer air was doubtless considerably drier and hence it was possible for the surface fog and cloud to evaporate as actually happened later in the day.

The morning weather map gives a rather illuminating view of the weather conditions that prevailed at the time of the flight. An area of high pressure with its crest over New England, 30.50 inches, was passing to the eastward over the Atlantic. A dense layer of cloud overspread practically the whole country including the Atlantic coast, altho pressure in the last-named district exceeded 30.40 inches. At Asheville, N. C., light snow was falling with a southeast wind, thus showing that the conditions which existed at Mount Weather were common along the eastern slope of the Appalachians.

The kite flights at Mount Weather have repeatedly shown that the surface winds in areas of high pressure passing off to sea over the Atlantic coast are very shallow, and that at a few hundred meters above the mountain top warmer westerly winds prevail. On the border between the two wind systems there is always a rather thin cloud layer which under favorable conditions may increase in depth and produce rain.

But on the map in question the particular point to which I wish to draw attention is the rise of 20° F. in the surface temperature in Oklahoma, and also in the lower Lake region, while at Mount Weather a layer of warm air, relatively to the surface, prevailed at an altitude of about 500 meters above the station. It is the experience at Mount Weather that horizontally moving air currents having a temperature relatively higher than that of the surface descend rather slowly; thus a warm current, which first appears on the mountain top, has been known to require about twenty hours in the descent into the adjacent valleys, as shown at Trapp, 309 meters lower on the Loudoun side, and at Audley (near Berryville) on the Shenandoah side. It is assumed, therefore, that the surface warming shown on the weather map some distance from Mount Weather is evidence of the descent, during the previous twenty-four hours, of the layer of warm upper air which was observed at Mount Weather on the day in question. As a matter of fact the warm layer reached the surface at Mount Weather in about twenty-four hours after the kite observation.

[1] This was at the highest point attained by the kite in this ascent.

A PORTABLE ROTATION PSYCHROMETER.

By P. J. O'GARA, Assistant, Bureau of Plant Industry. Dated New Castle, Cal., January 16, 1909.

A form of psychrometer, designed to take the place of the ordinary sling psychrometer where it is impossible to use the latter, such as in thickets or heavily-wooded areas, or in caves where humidity readings are desired, is shown in fig. 1. The instrument consists of a large bevel gear, provided with a crank which drives a small gear. The axis, around which the small gear turns, carries a light steel frame which is revolved by the small gear and to which the wet- and dry-bulb thermometers are attached. This steel frame is so formed as to protect the thermometers, and being constructed of steel bands which are channeled it is sufficiently stiff to resist bending, making it almost impossible to break the thermometers. In the instrument shown in fig. 1 the ratio of the large gear to that of the small one is such that a linear velocity of 25 feet or more per second may be given to the thermometer bulbs, thus providing the means for rapid evaporation from the wet-bulb thermometer. This form of psychrometer is

particularly useful in certain lines of botanical research, especially in ecology where relative humidity readings must form the basis of a large part of the work. The one advantage of the machine is its compactness, making it easily portable with little danger of accidental breakage. Furthermore, the cost of construction is little more than the cost of a good pair of thermometers which should be 8 or 10 inches in length. If

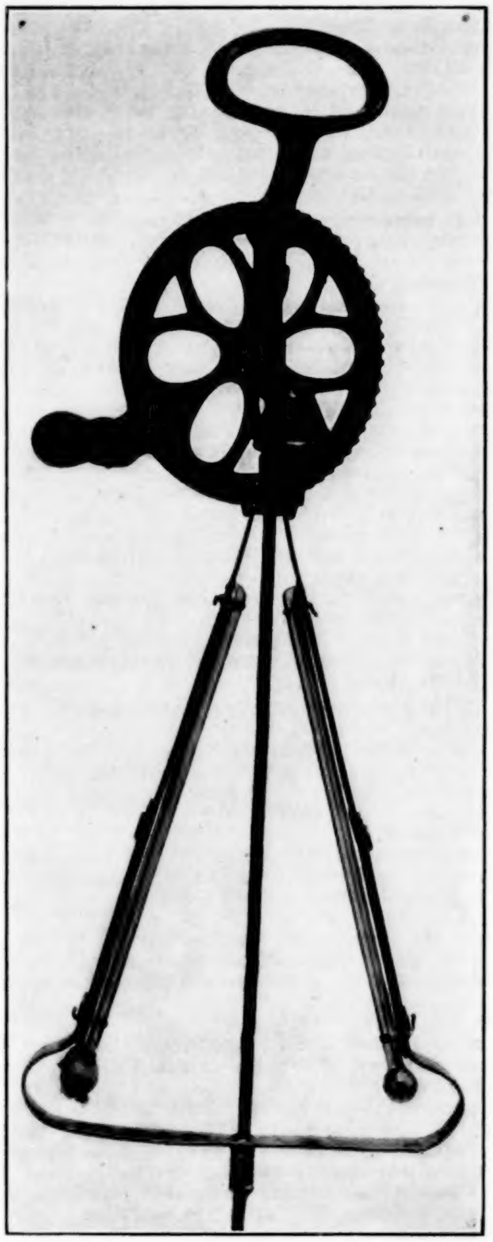

Fig. 1.—O'Gara's portable rotation psychrometer.

desired, the axis, around which the frame and thermometers turn, may be prolonged some distance beyond the end of the frame and rest against a tree or other fixt object while whirling. However, in order to insure accuracy in the results, the instrument should be moved about as much as possible, or as far as the space will allow, while it is being whirled. The writer has constructed several of these instruments and has found no difficulty in getting just as accurate readings as with the standard psychrometer now in use at the different Weather Bureau stations.

THE PSYCHROMETER: ROTATED, WHIRLED, VENTILATED.

The preceding article by P. J. O'Gara is welcome as showing that at least one of the modern improvements in psychrometry has been accepted by biologists, viz, the necessity of ventilation. There are other matters quite well worth considering. The formulas and tables devised by Ferrel and those used in both American and German weather bureaus are constructed for thermometers with cylindrical bulbs; appreciable changes in these tables are required if, as indicated in Mr. O'Gara's drawing (see fig. 1), spherical bulbs are used. This change is not wholly a question of convenience or sensitiveness, but arises from the differences in radiation, absorption, and evaporation between spherical and cylindrical surfaces. Anyone intending to use the published tables should provide himself with thermometers having cylindrical bulbs.

Mr. O'Gara has devised an arrangement that is safer and more convenient than the sling psychrometer for use close to the ground and in other contracted localities where the ordinary sling can not be used. Both this device and the sling are, however, inferior in accuracy to those forms of apparatus in which the thermometers are whirled in shelters or enclosed in separate tubes and the air drawn over them by some convenient method. Assmann uses a centrifugal fan attached to one end of the ventilation tube, and his fan may be driven by clockwork or electric motor. One could easily substitute a fan driven by hand or any other mechanical agency. All these details, however, involve increased cost and complication, and the O'Gara device is very good where results of the highest accuracy are not essential. If it is desired to ascertain the moisture in a very limited portion of air, we accomplish this by simply pointing the ventilation tubes into that air and working the fan. As the ventilation tubes protect the thermometer from radiation, Assmann's apparatus gives more correct temperatures and moistures than unprotected thermometers.

A high grade of thermometer is necessary in psychrometric work, since it is the difference between the dry-bulb and wet-bulb that enters the psychrometric tables, and this difference should be correct to within a tenth of a degree, an accuracy that is not attained by ordinary thermometers. The velocity of ventilation, or rotation of the thermometers, should be between 15 and 25 feet per second in order to harmonize with the velocities used in obtaining the data on which the standard psychrometric tables are based. The Weather Bureau tables are not applicable to the stationary unventilated wet-bulb thermometer with coarse cotton wick extending down to a vessel of water. In fact, that older form of psychrometer is too crude to give results at all comparable in accuracy with modern good methods.

From a meteorological, or a hygienic, or a biological point of view it is often of more importance to ascertain correctly the general condition of a large mass of air than the exact condition of a specific small mass. The former desideratum is best attained by using some form of rotating or whirling psychrometer freely exposed to the wind;[1] the latter is attained by using the form of psychrometer recommended by Belli and perfected by Assmann, which draws the specific mass of air directly past and close to the thermometer bulbs.

Still higher accuracy is of course attained by using some perfected form of dew-point apparatus, but this deals with a still more limited quantity of air that is temporarily in immediate contact with the bedewed surface.—*C. A.*

WEATHER BUREAU MEN AS EDUCATORS.

H. W. Grasse, Assistant Observer, Moorhead, Minn., reports that a class of 42 students from the Moorhead State Normal School visited the local office on January 19 and 20.

[1] Doctor Craig used a sling, but enclosed the thermometer in thin metallic tubes.

Eric R. Miller, Local Forecaster, Madison, Wis., reports that he has been requested to give instruction in meteorology and climatology at the University of Wisconsin. The course will begin in February and continue until June.

H. W. Richardson, Local Forecaster, reports that a class of 20 students from the Superior, Wis., State Normal School visited the Duluth, Minn., office on January 18; and on January 21, 40 students from the Finnish National College, Smithville, Minn., visited the Duluth, Minn., office and had the workings of the Bureau explained them thru an interpreter.

M. R. Sanford, Local Forecaster, Syracuse, N. Y., reports that on December 10, 1908, the class in physical geography of the Fayetteville, N. Y., High School visited the Syracuse office. On December 14, 1908, Mr. Sanford delivered an address at the new High School auditorium; on January 4 and 20 he spoke before local church clubs.

J. Warren Smith, Section Director, Columbus, Ohio, reports that he resumed the regular course in meteorology at the Ohio State University the first week in January. This course of two hours weekly during twelve weeks of the winter term is required of juniors in the College of Agriculture. He also delivered three lectures before 250 students in the Short Course of that college. The class in meteorology at the State University visited the local office on January 14 and 15. A class from the High School for Girls visited the office on the 19th.

C. D. C. Thompson, Observer, gave an informal talk on January 15 before the Mens' Club of Trumbull Avenue Presbyterian Church, Detroit, Mich., about the Weather Bureau and its work.

J. F. Voorhees, Local Forecaster, Knoxville, Tenn., reports that on January 26 and 27 he gave, at the invitation of the Tennessee State Nurserymens' Association, a talk on "The relation of the U. S. Weather Bureau to fruit growing in Tennessee."—*C. A., jr.*

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Librarian.

The following have been selected from among the titles of books recently received, as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies. Most of them can be lent for a limited time to officials and employees who make application for them. Anonymous publications are indicated by a ——.

American climatological association.
Transactions. 1908. v. 24. Philadelphia. xxii, 290 p. 8°.

Austria-Hungary. K. k. Central-Anstalt für Meteorologie und Geodynamik.
Jahrbücher . . . Jahrgang 1906. Neue Folge. 43. Band. Wien. 1908. f°.

Bologna. Università. Osservatorio.
Osservazioni meteorologiche 1907. Bologna. 1908. 31 p. f°.

Bulgaria. Institut météorologique central.
Bulletin sismographique. no. 3. Sofia. 1908. 43 p. 8°.

Calvert, Philip P.
Map showing the distribution of actual mean annual temperatures in Mexico and Central America. (From Biologia Centrali-Americana. London.) 26 x 32 cm.

Chemulpo (Korea). Meteorological observatory.
Results of the meteorological observations made at the Japanese meteorological stations in Korea. 1907. Chemulpo. [1907-8.] f°.

Dechevrens, Marc.
Les phénomènes de température dans les tourbillons et en particulier dans la haute atmosphère. Roma. 1908. 34 p. 4°. [Estratto dalle Memorie della pontificia accademia romana dei nuovi Lincei. v. 26.]

Dutch West Indies. Inspectie van den Landbouw.
. . . Meteorologische waarnemingen gedaan op de meteorologische stations in den colonien Suriname en Curaçao. 1907. [Paramaribo. 1908. 16 p.] 8°.

Eiffel, G.
Atlas météorologique pour l'année 1907 d'après vingt-quatre stations françaises. Paris. 1908. 51 p. 24 pl. f°.

Eredia, Filippo.
La siccità del 1908 nelle Puglie. Roma. 1908. 5 p. 4°.
Sulla misura della neve. Roma. 1908. 8 p. 8°.

Flammarion, Camille.
Annuaire astronomique. 1909. 45 année. Paris. [1908.] 315 p. 12°.

Hamburg. Deutsche Seewarte.
Monatskarte für den nordatlantischen Ozean. Hamburg. 1908. 12 charts. 92 x 62 cm.

Hann, Julius.
Handbuch der Klimatologie. 1. Band: Allgemeine Klimalehre. 3. Auflage. Stuttgart. 1908. xiv, 394 p. 8°.

Haynald Observatorium.
. . . Meteorologische Beobachtungen angestellt zu Boroma in Süd-Africa . . . 1891-1892. Kalocsa. 1896. 75 p. f°. (Publicationen des Haynald-Observatoriums. 7 Heft. 1896.)
. . . Meteorologische Beobachtungen . . . zu Boroma und Zumbo in Süd-Africa 1893-1897. Kalocsa. 1905. 94 p. f°.

India. Meteorological department.
Memorandum on the meteorology of India during October and November, 1908 . . . Calcutta. 6 p. f°.

International meteorological committee.
Report of the 8th meeting . . . Paris, September, 1907. London. 1908. 101 p. 8°.

Inwards, Richard.
Weather lore; a collection of proverbs, sayings, and rules concerning the weather. 3d ed. London. 1898. xii, 233 p. 8°.

Latham, Baldwin, *and others.*
Upon the effects of rainfall on the flow of sewage. (Great Britain. Royal commission on sewage disposal. Supplementary volumes presented with the fifth report of the commissioners appointed to inquire and report what methods of treating and disposing of sewage . . . may be properly adopted. London. 1908. 198 p. f°.)

Klossovskii, A.
Page finale des journaux "Revue météorologique" (Travaux du réseau météorologique du sud-ouest de la Russie 1887-1908) et "Annales" de l'Observatoire météorologique et magnétique de l'Université impériale à Odessa. Odessa. 1908. v, 104 p. 8°. (Russian.)

Knott, Cargill Gilston.
The physics of earthquake phenomena. Oxford. 1908. xii, 281 p. 8°.

Kremsmünster. Sternwarte.
Resultate aus den in den Jahren 1905 and 1906 auf der Sternwarte zu Kremsmünster angestellten meteorologischen Beobachtungen. Linz. 1908. 88 p. 8°.

Leipzig. Erdbebenstation des palaeontologisch-geologischen Institutes.
. . . 10[ter] Bericht der Erdbebenstation Leipzig. (Abdruck aus den Berichten der mathematisch-physischen Klasse der Königliche sächsischen Gesellschaft der Wissenschaften zu Leipzig. 60. Band. Sitzung vom 20. Juli 1908.)

Martin, Edward A.
Some considerations concerning dew-ponds. South Norwood. (Reprinted from the Transactions of the Southeastern union of scientific societies. 1908.) p. 66-85. 8°.

Merveille, E.
. . . La section magnétique. Édition française. Barcelone. 1908. 74 p. f°. (Mémoires de l'Observatoire de l'Ebre sis à Roquetas. Dépendant du College d'études supérieures de la Cie de Jésus de Tortosa . . . no. 3.)

Mill, Hugh Robert.
The rainfall of Kent. [From the "Water supply of Kent," Mem. Geological survey, 1908, pages 20 to 27.] 1908.

Moore, Edward.
A cloudburst in the high Sierra. (Bulletin of the California physical geography club. Berkeley. v. 2. Dec., 1908. p. 24-27.)

Palmer, W. S.
Wyoming's climate, and its effect on crop production. (*In* The third Trans-Missouri dry farming congress at Cheyenne, Wyoming, Feb. 23d, 24th, and 25th, 1909 . . . Cheyenne. 1909. p. 51-54.)

Poincaré, Lucien.
. . . The new physics and its evolution. London. 1907. xv, 344 p. 12°.

Prussia. Königliches preussisches aeronautisches Observatorium bei Lindenberg.
Ergebnisse der Arbeiten . . . 1907. Braunschweig. 1908. xxi, 115 p. f°.

Richter, C. M.
The relation of anticyclonic weather to the prevalence of la grippe and pneumonia on the northern hemisphere with special reference to recent epidemics of pneumonia in Chicago and San Francisco. Chicago. 1908. 11 p. 8°. (Reprinted from the Journal of the American medical association, Aug. 22, 1908, v. 51, p. 660-663.)

[Rykachev, M. A.]
Liste préalable des travaux sur les régions arctiques publiés en Russie de 1883 à 1906. St. Pétersbourg. 1906. 16 p. 8°.

Sinclair, W. J. H.
. . . The weather and climate of Peterhead. Peterhead. 1905. 30 p. 8°. (Reprinted from the Transactions of the Buchan field club.)

Smithsonian institution.
Annual report ... 1907. Washington. 1908. lvii, 726 p. 8°.
Tananarive. Observatoire de Madagascar.
Observations météorologiques. 1907. Tananarive. 1908. vi, 271 p. 8°.
Thomson, J[oseph] J[ohn].
Elements of the mathematical theory of electricity and magnetism. 3d edition. Cambridge. 1904. viii, 544 p. 12°.
Titchener, E. B.
The psycophysics of climate. (Reprinted from the American journal of psychology. Jan., 1909. v. 20, p. 1-14.)
U. S. Coast and geodetic survey.
United States magnetic tables and magnetic charts for 1905. Washington. 1908. 154 p. f°.
Voeikov, A[leksandr].
Klimat Poliesia. St. Petersburg. 1897. 28 p. 8°. (Russian.)
West Indies. Imperial department of agriculture.
Barbados. Report of the agricultural work. pt. 3, 1905-7. Barbados. 1908. 99 p. f°.
Wiesbaden. Meteorologische Station.
Ergebnisse der meteorologischen Beobachtungen der Station II. Ordnung Wiesbaden im Jahre 1907. Wiesbaden. 1908. 54 p. 8°. (Sonderabdruck aus den Jahrbüchern des Nassauischen Vereins für Naturkunde. Jahrgang 61.)

RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. FITZHUGH TALMAN, Librarian.

The subjoined titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers or other communications bearing on meteorology or cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled; it shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau. Unsigned articles are indicated by a ——

American geographical society. Bulletin. New York. v. 41. Jan., 1909.
Ward, Robert DeC. Tuberculosis and climate. p. 22-23.
American society civil engineers. Proceedings. New York. v. 35. Jan., 1909.
Matthews, Ernest R., and Watson, James. The action of frost on cement and cement mortar, together with other experiments on these materials. p. 2-14.
Astrophysical journal. Chicago. v. 29. Jan., 1909.
Humphreys, W[illiam] J[ackson]. Vertical temperature gradients of the atmosphere, especially in the region of upper inversion. p 14-32.
Electrical review. Chicago. v. 54. Jan. 23, 1909.
—— An electric hygroscope. [Abstract of paper by Pionchon.] p. 157.
Electrical world. New York. v. 53. 1909.
Carpenter, Daniel S. The theory of lightning. (Jan. 7.) p. 111-113; (Jan. 14.) 158-161.
Engineering news. New York. v. 61. Jan. 28, 1909.
Forests and snow in the high mountains. p. 100.
Geographical journal. London. v. 33. Feb., 1908.
Oldham, R. D. The Italian earthquake of December 28, 1908. p. 185-188.
M., H. R. The meteorology of the "Discovery." p. 188-191. [Review.]
Meteorological society of Japan. Journal. Tokio. 27th year. Dec., 1908.
Tamura, S. T. Prof. Cleveland Abbe and his work. [Japanese.]
Nature. London. v. 79. Dec. 17, 1908.
Meteorology in South Victoria Land. [Abstract of "National antarctic expedition 1901-4, Meteorology, pt. 1."] p. 202-203.
Nature. London. v. 79. Jan., 1909.
Meteorological reports by wireless telegraphy. [Note on experiments to be conducted by Meteorological office and Deutsche Seewarte.] p. 287. (Jan. 7.)
O., R. D. The Italian earthquake. (Jan. 7.) p. 287-289.
—— Prof. J. M. Pernter. (Jan. 7.) p. 280.
O., R. D. Recent earthquakes. (Jan. 28.) p. 368-369.
London, Edinburgh, and Dublin philosophical magazine. London. 6 series. v. 17. Jan., 1909.
Morton, W. B. Note of the amount of water in a cloud formed by expansion of moist air. p. 190-192.

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Physical review. Lancaster. v. 28. Feb., 1909.
Nichols, Edward L. A study of overcast skies. p. 122-131.
Popular science monthly. New York. v. 74. Feb., 1908.
Hobbs, Wm. H. The latest Calabrian disaster. p. 134-140.
Science. New York. v. 29. 1909.
Reid, Harry Fielding. Mr. Manson's theory of geological climates. (Jan. 1.) p. 27-29.
Gilbert, G. K. Earthquake forecasts. (Jan. 22.) p. 121-138.
Pemberton, Henry, jr. Peculiar electrical phenomena. (Jan. 22.) p. 143.
Scientific American. New York. v. 100. Jan. 23, 1909.
Murray, W. J. The scientific aspect of earthquakes and volcanoes. p. 82-83.
Scientific American supplement. New York. v. 47. 1909.
Jagar, Thomas A. The Messina earthquake. Prediction and protection. (Jan. 22.) p. 58.
—— The Italian earthquake. [Text reprinted from Nature. Illustrations from several English weeklies.] (Jan. 30.) p. 71-74.
Annales de géographie. Paris. 18 année. 15 jan., 1909.
Lessèp, R. Le climat de la Kabylie du Djurdjura. p. 24-33.
Marc, Lucien. La répartition de la pluie entre la côte de Guinée et le sommet de la boucle du Niger. p. 34-45.
Denis, Pierre. Le Ceara. p. 46-62. [Includes description of the climate.]
France. Académie des sciences. Comptes rendus. Paris. v. 148. 1909.
Birkeland, Kr. Les orages magnétiques polaires et les aurores boréales. (4 jan.) p. 30-33.
Garrigou-Lagrange, P. La pluie et les sources en Limousin en 1908. (4 jan.) p. 60-62.
Angot, Alfred. Sur le tremblement de terre du 28 décembre 1908. (4 jan.) p. 62-63.
Montessus de Ballore, Fernand de. Sur une interprétation possible des ondes de la phase principale des sismogrammes. (18 jan.) p. 200-201.
Sola, J. Comas. Le tremblement de terre du 28 décembre 1908, enregistré à l'Observatoire Fabra (Barcelone). (18 jan.) p. 202-203.
Nature. Paris. 37. année. 1909.
De Launay, L. Le cataclysme de Messine. (9 jan.) p. 82-83.
L., D. L. Le désastre Italien. (16 jan.) p. 103-106. [Illustrated.]
Fournier, Lucien. La résistance de l'air. (23 jan.) p. 114-117.
—— Tremblements de terre et mines. (23 jan.) p. 57, suppl.
Revue néphologique. Mons. Nov., 1908.
Schmidt, Wilhelm. Observations sur l'orientation des cristaux de glace dans les nuages. p. 273-277.
Deutsche Mechaniker-Zeitung. Berlin. 1. Oktober 1908.
Disch, Johann. Tafel zur ungefahren Ermittelung der Luftfeuchtigkeit für Temperaturen von 40° bis 100°. p. 181-184.
Himmel und Erde. Berlin. 20. Jahrgang. Okt., 1907.
Mecking, L. Die Forschungstätigkeit von S. M. S. "Planet." p. 19-34. [Contains account of aerological observations and methods. Illustrated.]
Geographische Zeitschrift. Leipzig. 14. Jahrgang. Dez., 1908.
Polis, P. Die meteorologische Organisation der Vereinigten Staaten. p. 658-666.
Lindenberg. Aeronautisches Observatorium. Ergebnisse. Braunschweig. 3. Band. 1907.
Coym, Arthur. Ueber die absolute Messung der Intensität der Sonnenstrahlung in Freiballon. p. 111-115.
Prometheus. Berlin. 20. Jahrgang. 13. Jan., 1909.
J., —. Neue Versuche mit Blitzableitern. p. 232-234. [Abstract of paper by M. Hopkins.]
Weltall. Berlin. 9. Jahrg. 1909.
Krebs, Wilhelm. Das Erdbeben vom 14. Januar 1907 und seine Begleiterscheinungen. (1 Jan.) p. 103-107; (15 Jan.) 113-122.
Habenicht, H. Trockenperioden und Erdbeben. (15 Jan.) p. 127-128.
Wetter. Berlin. 25. Jahrgang. December 1908.
Kienast, [Hermann]. Wettervoraussage vor 180 Jahren. p. 265-273.
Joester, Karl. Die Föhnerscheinungen im Riesengebirge. p. 273-280.
Rudel, [K.]. Trockenperioden. p. 284-285.
Polis, P. Drahtlose Telegraphie und Wetterdienst. p. 285-288.
Zeitschrift der Gesellschaft für Erdkunde. Berlin. 1908.
Baschin, Otto. Die klimatischen Verhältnisse der Stadt Berlin. p. 539-548.
Hellmann, G[ustav]. Ueber die extremen Schwankungen des Regenfalls. p. 605-615.
Hemel en dampkring. Amsterdam. 6. Jaargang. December 1908.
S., C. Een bezoek aan Hr. Ms. *De Ruyter*. p. 113-115. [Describes aerological equipment of the Dutch man-of-war *De Ruyter*.]
S., —. De hoek tusschen drukverval en windrichting. p. 115-117.
—— Volkswijsheid over het weer. p. 127-128. [Gives a number of Dutch weather proverbs.]

THE SOURCE OF OUR COLD WAVES.

By Director R. F. STUPART. Dated Toronto, March 3, 1909.

I send you the January tracks (Chart IX) and the tracks for the other months will follow almost immediately. I also send you a map (Chart X) with the isobars drawn based on the reports from the far north stations.

A comparison of the mean barometric pressures in the far north for January, 1907, and January, 1908, is most interesting. In the former year the mean pressure at Dawson was 30.70 inches (sea level) and the distribution of mean pressure over Canada and the Northwestern States led to a persistent northeasterly gradient over the whole northern region, and hence extremely cold weather was experienced between latitudes 60° N. and 45° N. It is worthy of note, however, that the Dawson temperature in latitude 64° N. was only just normal. In 1908 the mean pressure at Dawson was 29.90 inches, and there was a totally different distribution of pressure over the Western States and northern Canada; the prevailing gradient was for southwesterly winds. The whole of our Western Territories were decidedly warmer than the average. It appears fairly evident that the wide negative departures in Alberta and Saskatchewan during January, 1907, and again in this past January, were perhaps altogether due to the persistent transference of air from the higher latitudes, and the equally wide positive departures in 1908 were due to the equally persistent southwesterly gradient.

I believe that a study of the far north with reliable barometer readings will be most valuable. Apparently the high pressures in Yukon are not wholly the outcome of extreme cold caused by radiation. The coldest January of which we have record was that of 1906, when the mean pressure was 30.26 inches and the mean temperature —34°, while in southern Saskatchewan and Alberta that month was phenomenally mild, with persistent southwesterly winds.

The high pressures in Siberia are certainly not altogether the outcome of the continental cold, as the lowest temperature is far north of the highest mean pressure, which is an extension and an intensification of the extratropical belt of high pressure. It thus appears to me that the persistent high pressures found in some seasons in the far north owe their origin to upper currents from the equator coming to earth farther north than usual. Indeed the formation of the ordinary high is probably due to this, but we may very probably in the future connect the situation in the equatorial regions and trade-wind belts with that in the high latitudes.

THE CLIMATE OF THE GLACIAL EPOCH.[1]

By HENRYK ARCTOWSKY, Brussels.

[Translated by C. Abbe, jr.]

It is well known that the snow line at any locality does not depend solely on the local mean temperature, but is also determined by other climatic factors, such as the amount of insolation and the character of the seasons. The local topography and the amount of annual precipitation are also equally important.

In order to determine the influence of one of the factors, e. g., the temperature, it is necessary that all the other factors remain constant. Thus, let us suppose for the sake of simplicity that we have an isolated mountainous island in the ocean, and that this island may shift its position along its meridian. If the island is moved into a region where all the climatological conditions except temperature remain the same, then the change in altitude of the snow line will express the influence of the variable factor.

To determine the fall in the mean temperature of a given region during the glacial epoch, at least in a wholly marine climate, it would be necessary to find a second identical region exposed to the same winds, having the same cloudiness and precipitation, and whose actual present glaciation has the same extent as did the previous glaciation of the first region.

Now it seems to me that we should be able to find some examples of this kind somewhere in the Southern Hemisphere; but the difficulties are undoubtedly numerous, and we may not hope to find more than a mere approximation to the climatic conditions of the glacial epoch.

Thus, as is well known, the atmospheric precipitations of mountainous regions are not the same at all heights, whence we may conclude that they would very probably show similar variations on an isolated island. As we advance toward the poles, or the colder regions, the zone of maximum precipitation having entered the zone of snowfall experiences a sudden change, and at once the limit of snowfall will descend more slowly with the progressively diminishing rate at which the temperature falls. But here enters another difficulty, viz, the altitude of the clouds seems to diminish with increasing latitude.

Furthermore, the courses of the ocean currents may have changed since the glacial epoch, or to speak more accurately—since the surficial marine currents depend almost entirely on the prevailing winds—the region of equatorial calms may have shifted, the trade winds, the permanent highs, and the tracks of cyclonic storms may have occupied quite different positions from what they do to-day. Croll's hypothesis[2] requires this, and the fact that there were extensive glacial ice caps renders it yet more probable.

Again, there is a no less important difficulty, the present positions of the glaciated lands with reference to sea-level are in many cases no longer the same as during the time of maximum glaciation, and Rudzki[3] has demonstrated the probability of the submersion of the lands under the weight of accumulated ice.

In any case, then, a more profound study of the region will have to consider the question: By how many degrees centigrade must the mean temperature be lowered (every thing remaining the same in other respects) in order to lower the line of permanent snow by n meters?

So far as concerns the Alps Penck admits that the permanent snow line there stood lower by about 1,000 meters, and Brückner believes that the mean temperature of the glacial epoch at the time of maximum glaciation was only 3° or 4° C. lower than it is to-day.[4] Oswald Heer[5] was also led, by his paleontological studies, to the conclusion that the mean temperature was then lower by 3° or 4° C.

Nevertheless it seems to me that these figures do not suffice unless we admit, a priori, a climate much more humid than the present, and that a much greater difference in temperature is necessary to lower the snow line by 1,000 meters if the precipitation was the same then as now.[6]

To demonstrate this I compare the region of Cape Horn with the island of South Georgia, the latitude of both is the

[1] This article appeared in the Bulletin de la Société Belge d'Astronomie, Juin, 1908, No. 6, p. 220-231, as an extract from the author's memoir on the present and former glaciation of the channels of Tierra del Fuego and the Antarctic Continent, as discovered by the *Belgica*, about to appear in the Rapports scientifiques de l'expedition antarctique belge.

[2] James Croll: Climate and time. London. 1875.
G. Pilar: Ein Beitrag zur Frage die Ursachen der Eiszeit. Agram. 1876. Pilar, starting with Croll's idea, demonstrated that the tropical calm belt was necessarily displaced; but did not take account of the influence of this shifting upon the general atmospheric circulation of the whole globe.

[3] Rudzki. Bul. internat. de l' Acad. des Sci. de Cracovie, 1899, p. 169.

[4] Klimaschwankungen seit 1700. Vienna. 1890. p. 308.

[5] See A. Heim: Handbuch der Gletscherkunde. Stuttgart. p. 560.

[6] T. G. Bonney thinks that it would require a lowering of 18° F. (10° C.) to produce a glacial epoch if the temperature distribution of the Northern Hemisphere remained the same as to-day. See Geog. Jahrb., 1893, p. 24.

same, 54° south; the difference in longitude is 30°. Both have a marine climate with prevailing west winds.

Station.	Mean temperature.	Days with rain or snow, 1882-83.	Precipitation.	Snow line.
	° C.		Mm.	Meters.
Cape Horn [7]	5.5	278	1,400	900
South Georgia [8]	1.4	301	900	600
Differences	4.1	....	500	300

The difference in precipitation is due, without doubt, to differences in the exposure of the observing stations, and probably as a matter of fact the precipitation is the same at corresponding altitudes at both places. From the geomorphologic point of view the islands west and south of Tierra del Fuego are comparable in all respects with the island of South Georgia. The altitude of the perpetual snow line in the Magellanic region[9] is 900 meters, while on the northeast coast of South Georgia[10] it stands at 600 meters.

Together with a difference of 4° C. in the mean temperature there is here a difference of about 300 meters in the two levels of perpetual snow.

In fact it seems to me useless to insist any longer on the example selected, since the elevation of the line of perpetual snow is not sufficiently well known, while our knowledge of the topography of South Georgia and of the islands of Tierra del Fuego is even less satisfactory.

Moreover, this example will inevitably be criticised, and without doubt those geologists holding to the theory of a moister climate will point out that the level of the line of perpetual snow corresponds with a great variety of isotherms, ranging between the isotherms of +3° in the Andes near Quito and that of —10° or —11° C. in Spitzbergen and Nova Zembla,[11] or even more. In fact, one may readily accuse me of partiality and claim that the above example has been chosen with the direct purpose of showing that the climate of the glacial epoch must have been much more rigorous than we have presumed. It will certainly be maintained that only a general discussion of all the known facts can have decisive value, and that in any case we should take the mean of all the numbers obtained. I do not contest this, but nevertheless in the actual state of our knowledge it is preferable to limit ourselves to the selection of illustrations from regions where the climate is now and has been essentially marine, choosing by preference oceanic islands. Therefore the example given seems to me well chosen.

Another good example deserving of thoro study and discussion is the comparison of the region about the Straits of Tierra del Fuego with the antarctic continent lying south of Cape Horn. Both regions are mountainous and exposed to oceanic winds, which bring abundant precipitation; but the altitude of the snow-line in the polar lands is lower by about 800 meters, and the actual appearance of this land is very probably that which the region about the Straits of Tierra del Fuego must have presented at the time of maximum extension of Pleistocene glaciation. What, now, are the mean temperatures of these two regions? We have but few available data for the Straits of Tierra del Fuego and still less for the antarctic lands. The known means are as follows:

[7] Lephay: Mission scientifique du Cape Horn. Vol. II, p. 138.
[8] Die Internationale Polarforschung, 1882-3. Die Beobachtungs Ergebnisse der Deutschen Station. Vol. II, p. 138.
[9] According to the officers of the *Beagle*, 1,000 meters; according to Pissis, 800 meters; according to Thomas Bridges, 900 to 1,000 meters.
[10] Hann: Klimatologie. 1897. Vol. III p. 467.
[11] Hann: op. cit., I, p. 313. See Hann-Ward, 1903, p. 321-322.

Magellanic region.	° C.	*Antarctic region.*	° C.
Punta Arenas [12]	6.7	Snow Hill [16]	—11.8
Ushuwaia [13]	6.5	Scotia Bay [17]	— 5.4
Cape Horn [14]	5.5	Wandel Island [18]	— 5.4
Staten Island [15]	6.3		

We thus have a difference of level of the snow line of 800 to 900 meters, corresponding to a difference in the mean temperature of at least 10° to 12° C.

If a more thoro study of the topography and the meteorological conditions of the two regions permits us to maintain this analogy, the data already secured will not fail to clear up a part of the problem of the climate of the glacial epoch. We may at least determine how many degrees fall in temperature must occur in the Magellanic region in order that the ice again descend to the level that it then occupied. I would emphatically declare that when one speaks of the lowering of temperature that accompanied the glacial epoch in the Magellanic region and sets the same at 4° C. one speaks as tho this number applied indifferently to all the regions of the globe.

Now it is inconceivable that inland ice caps such as existed in northern Europe and North America, should not have profoundly modified the meteorological regimen of neighboring regions and even the general atmospheric circulation of the whole Northern Hemisphere. The distribution of climates, even in the regions beyond the ice-invaded country, must have been incontestably at variance with the present, so that for this reason alone it seems to be inadmissable to assume that the fall in temperature went on in a similar manner everywhere, and that it may be exprest by a simple difference—and that the same difference—from the mean annual temperature.

A PLEA FOR TERRESTRIAL AND COSMICAL PHYSICS.[1]

By Dr. L. A. BAUER, Carnegie Institution of Washington. Dated December, 1908.

Once upon a time, at a certain small dinner party, the Duke of Wellington on being urged to express his opinion frankly of the French marshals he had so successfully worsted in battle, pointed out their good qualities in a most free and magnanimous manner, showing wherein each particularly excelled. Whereupon one of the party said, "Well, sir, how was it that with such various great qualifications you licked them all, one after another?" The Duke, taken a-back, paused, then said, "Well, I don't know exactly how it was, but I think if any unexpected circumstances occurred in the midst of a battle which deranged its whole plan, I could perhaps organize another plan more quickly than most of them."

This quality of mind, to instantly change an established train of thought or to be receptive to a new set of circumstances and facts, and thus to be capable of immediately setting up a fresh plan of action, was tersely and most suggestively exprest by Maxwell when writing Herbert Spencer about a subject of controversy in the latter's "First Principles:"

> It is seldom that any man who tries to form a system can prevent the system from forming around him and closing him in before he is forty. Hence the wisdom of putting in some ingredient to prevent crystallization and keep the system in a colloidal condition.

At the Ithaca meeting of the Association two years ago last summer, I prefaced a paper on the San Francisco earthquake by a few remarks calling attention to the disparity of papers pertaining to the physics of the earth and of the universe presented to-day before Sections A and B. I stated it was

[12] Arctowsky. Ciel et Terre, 16 juin 1900.
[13] Lephay: Mission scientifique de Cap Horn. Tome II, p. 138.
[14] Lephay: ibid., p. 271.
[15] Arctowsky. Ciel et Terre, 1 decembre 1900.
[16] Bodman. Petermann's Geogr. Mittheilungen, 1904, Hft. 5.
[17] Mossman, Scottish Geog. Mag., August 1905.
[18] J. J. Rey in Charcot: Les Français au Pole Sud. p. 367.
[1] Presented at the Baltimore meeting (1908-9) of the American Association for the Advancement of Science, before the General Interest meeting of Section B (Physics).

my impression that this had not always been the case. Attend any similar meeting abroad, be it in England, Germany, or France, and you find the names of foremost physicists down for papers on results of research in terrestrial or cosmical physics. These eminent investigators evidently find food for exhilarating thought and stimulating work in the unraveling of the phenomena of seismology, meteorology, geodesy, hydrology, atmospheric electricity, solar physics, terrestrial magnetism, etc. They appear to regard knowledge gained in the laboratory and in the university merely as a means to an end, not an end in themselves.

The chairman of the section of mathematics and physics at the recent meeting of the British Association was the well-known physicist-meteorologist, Dr. W. N. Shaw, director of the London Meteorological Office. Besides making a most suggestive presidential address, he led an interesting discussion on "The isothermal layer of the atmosphere," a live topic in meteorology to-day. Those taking part in the discussion were: Shaw, Rotch, Dines, Cave, Turner, Thomson, and Walker. Several times has it occurred within recent years at that association that owing to the number of titles presented it was necessary to have a subsection on "Cosmical Physics," which I am very glad to note did not apparently meet with the favor of the physicists themselves. Our British colleagues want the physicists to stay with them and not flock off by themselves, and the present tendency seems, accordingly, to be at the British Association not to form such a subsection. You will find among the past contributors to papers and discussions on this subject such names as, for example, Kelvin, Rücker, Schuster, Lockyer, Eliot, Cortie, Teisserenc de Bort, Glazebrook, Chree, Thomson, and others.

Doctor Shaw[3] well said that, "for the advancement of science in this sense we require all three: the professor, with academic freedom to illuminate with his genius any phenomenon which he may be pleased to investigate; the administrator, face to face with the practical problems in which science can help; and the living voice, which can tune itself in harmony with the advances of science and in sympathy with the needs of the people whom it serves."

I can not better illustrate this mutual help which may spring from friendly conference between the pure physicist and the "world-inoculated" one than to quote you a paragraph or two from a most admirable presidential address delivered by Dr. S. Weir Mitchell at the second meeting of the Congress of American Physicians and Surgeons, held at Washington in 1891, entitled: "The early history of instrumental precision in medicine." Referring to this congress of the eminent of the land in medicine and surgery, Dr. Mitchell says:

> It is here, therefore, that the open-minded may feel the broadening influence of intellectual contacts with those who have other limitations than his own; for, indeed, in our divergent attention to special studies we run some risk that, contrary to Saint Paul, the eye may say to the hand, "I have no need of thee," or the head to the body, "I have no need of thee," for as to us, also, "there should be no schism in the body." * * *
>
> What the specialist learns, until it is commonplace, is not easily enough assimilated by the mass of practitioners. At last, however, comes a time when it is, and then that whole body of medicine feels the gain in nutrition and repays the debt. The masters of our still most imperfect art, medical optics, may wisely remember that it was physicians who most distinctively recognized and diffused the knowledge that headaches and some other brain disorders are due to eye strain, and thus, while lessening our own futile labors, crowded the waiting room of the opthalmologist. * * *
>
> As I have mentioned the need for continuous individual cultivation of our multifarious science on a broad scale, and for personal consultation, I like to enlarge the plea and call a meeting like ours a general consultation. And this, in fact, it is; a focal point for condensed opinions, for authoritative statements, for criticism from varied standpoints, and for significant indications as to those accepted gains which ought to become from time to time a part of the mental equipment of all other special and, indeed, of all general practitioners.

[3] See Monthly Weather Review, December, 1908, 36:414.

Change the words physician, surgeon, medicine, to corresponding ones applicable to this gathering, and what apter or truer characterization of what our own aims and purposes should be, could be given than is embodied in these words. One is tempted to wish that we might also, like the "Deutscher Naturforscher und Aerzte Versammlung," of Germany, gather with us in annual conclave, the physicians and surgeons as well. Picture to yourselves the opportunities this would afford for enlivening and quickening discussions in several of our sections and you will appreciate what I am seeking to emphasize especially here, with regard to open, general meetings between the generalists and the "broadened specialists."

I say "broadened specialists" advisedly, for I believe upon critical examination it will frequently appear that the very pursuit of a specialty has a widening influence not adequately appreciated by one whose sphere of activity is restricted solely within the bounds of his own general science. For there is no more patent and suggestive fact of present-day research than that the most rapid achievements are not in the older, well-recognized sciences, but in their borderlands or "twilight zones." Thus the true research worker soon finds it necessary to make excursions into regions beyond what he had been regarding as his own particular zone. He makes new acquaintances, learns new customs and laws and gradually begins to preceive that there really is no well-defined line of demarcation, like the famous Great Wall of China, between one science and another.

One of the recent fundamental researches on the motion of the moon has been made by a college professor who tho an American resident got his chief training and inspiration at Cambridge, England. This same investigator has contributed articles on meteorological mechanics. Columbia University, in its admirable endeavor to present a popular course of lectures on subjects of applied physical science, must draw for its lecture on "Atmospheric Phenomena and Physical Theory," upon another foreign born, Cambridge-inspired, now American resident physicist. There are a number of you whose work lends additional eloquent testimony to the broadening and cosmical influence of that eminent school of physics. However, there are other European departments of physics of which much along similar lines could be stated and exemplified. Is it not possible to have more home-inspired university product to draw upon in these fields? Couldn't our country be more adequately represented on international comittees formed to consider and investigate some of the great world-wide questions? I do not believe we lack the talent. If there is less incentive among us, why is it?

The fact I wish to emphasize is strikingly shown by glancing for a moment at the general character of the papers presented before the section on general physical science in the first two decades of the history of the association. The papers classified under physics of the globe, meteorology, geodesy, and navigation, frequently exceeded those in physics, chemistry, mathematics, and astronomy, whereas now, as you all know, they are in a mimority. Among the authors of the first-named papers we find names which as soon as heard you will identify as among the most distinguished of the college professors of the middle of the last century: Redfield, Bache, Olmsted, Coffin, Alexander, Henry, Silliman, Peirce, Loomis, Espy, Horsford, Guyot, Lovering, Dana, Trowbridge, Mitchell, etc. Among the more eminent of those occupying government positions we find again Henry and Bache, and such men as Maury, Davis, Hunt, Hilgard, Schott, etc. The mental grasp of many of these geophysicists and cosmical physicists was considered sufficiently broad to make them desirable timber for the highest positions of honor in the Association.

In those "good old days" some of the best contributions in meteorology and terrestrial magnetism were made by the college professor. Bache made a magnetic survey of Penn-

sylvania early in the forties, while still a professor at Girard College, where he also established the first magnetic and meteorological observatory in this country; John Locke, the inventor of the electro-chronograph (which by the way is unique in the history of science in this country as being the only scientific invention, I believe, receiving an award from our Congress, viz, $10,000), in the thirties and forties undertook a magnetic survey of North America with Cincinnati as a base station. He even extended his investigations into Canadian territory and made many of the early observations of the three magnetic elements in the Eastern States. Locke was a contemporary of the astronomer Mitchel, holding the chair of professor of chemistry (inclusive of physics) and pharmacy at the Ohio Medical College. He lived at the time when the college professor frequently had to acquire his instruments of research and pay the expenses of his experiments out of his own meager salary. Yet he found ways of doing it and, moreover, seemingly had the necessary time to go beyond his classroom and extend his good work in the territory round about and far away.

Loomis's work on the aurora borealis is still quoted. The contributions to meteorology by Espy, Redfield, Coffin, Maury, and Loomis are known even to those of us who do not profess to be meteorologists. These few illustrations must suffice for our present purpose.

If the American college professor lacks the necessary time and incentive during the scholastic year, why doesn't he do as Bache, Loomis, and Nipher did, who spent their vacations in the open in order to learn something of the physical laws governing mutual phenomena?

Why is it that in spite of the truly wonderful spirit of research that has literally seized us in this country there are so few to be enrolled among those who are making definite contributions to terrestrial and cosmical physics? We find the American physicist very prominently represented, indeed, in astromony and astrophysics. May we not hope that he will soon realize that this planet on which we dwell and which must form the basis of all our astronomical speculations is also worthy of the highest and most unselfish devotion? That, indeed, to reap the full and most lasting benefit of our celestial researches we must keep equal pace with our terrestrial ones! Will he not recall that nearly every one of the great physicists he is so justly proud of citing has at one time or another extended his mental vision beyond the problems immediately before him and considered what the application of his laboratory discoveries might be toward solving some of the riddles of the universe, or how he might benefit mankind? Faraday, Maxwell, Kelvin, von Helmholtz, Hertz, Mascart, Langley, and Rowland are but a few of the inspiring names.

Happily, there are already some indications of a reawakening and we note with pleasure the example recently set by the retiring president of the Association (Prof. E. L. Nichols), who turned his sabbatical year to fruitful use in the study of some perplexing atmospheric phenomena, and whose retiring address was largely devoted to terrestrial and cosmical physics. We note movements at some of our large universities to expand their graduate courses in the direction of terrestrial and cosmical physics. There were twelve papers before sections A and B on the subjects under discussion.

Von Helmholtz, as many of you know, from actual experience, was a notoriously poor lecturer. He seemed utterly incapable of imparting his vast knowledge in any systematic manner, and doubtless the chief value which his listeners got was the inspiration imparted by class room association with this gifted man. Von Bezold, who delivered the Berlin memorial address on von Helmholtz, told me the latter gave as the reason of his inability to impart his acquired knowledge methodically, was because he, himself, had not gained it in that way. He would take up his mathematics, for example, only when he required it—not by going systematically and consistently thru a volume of higher analysis without some impelling or suggesting motive. And so it was with the other sciences with which he had to familiarize himself in order to push to successful completion an intricate and complex piece of research. Yet how truly marvelous was the grasp this man displayed in so many varied subjects!

Now who that has ever attempted to apply his knowledge to fields outside his own immediate one has not felt this same irresistible, impelling, burning desire to know all that had been done before him in the new country he is about to explore? Have not we each one of us found that with such an all-conquering impetus back of us, the most complex mathematics or the most abstruse subject teems with a new and living interest? What was irksome before has now become a pleasure. And if there is one of you who for lack of excursions into such green pastures, has not had new and invigorating blood course thru his veins and has not been given a glimpse of a higher, truer, and more ennobling vision of life, he has missed the greatest pleasure and the highest compensation open to the research worker!

Do you know of a school of thought that has prevailed for any length of time without resisting that most subtle and therefore most dangerous of all insidious modes of attack, viz, the one coming from within its own fold of devotees, due to the pernicious habit of in-breeding? Is there any greater danger than that which besets a university that fills its chairs repeatedly from among its own graduates? We all know of the fallacy of the brilliant professor who thinks his ideas can be made to continue longest by surrounding himself with assistants drawn, if not entirely, at least chiefly, from among his own disciples. Will he not surely find, as Maxwell put it, that his "system has closed him in before he is forty" because he has forgotten the element essential to prevent crystallization—the importation of fresh blood and the introduction of new ideas?

If you agree with the speaker thus far, may it not happen that precisely similar occurrences be recorded of our societies, because of the suicidal policy of a particular class of members who are apt to believe that the best result can be reached by increasing their representation, and thus by their majority vote be able to dictate and control the general policy of the society to which they belong? Is it a wise organization for membership in any deliberative scientific body to be so constituted as to make it possible for the act of the assembly to be unduly influenced by one set of investigators? Is there not here subject for careful thought—a source of degeneracy due to in-breeding in societies to be equally guarded against? Joseph Henry truly said: "Votes in science should not be counted, but weighed."

This, then, is my specific plea: A broader conception and a more scientific representation of the subjects of physical research. Could we not make the attempt certainly once a year to devote most of our time and attention to some of the greater aspects of our work and take stock, so to speak, of our achievements, and of their possible applications?

RETIREMENT OF PROFESSOR KLOSSOVSKII.

By Prof. ALEXANDER ZIWET, Ann Arbor, Mich. Dated February 6, 1909.

A. Klossovskii.—The last page of the journals "Meteorological Review" (Publications of the meteorological net of southwestern Russia, 1887–1908) and "Annals" of the magnetic and meteorological observatory of the Novorussian University [at Odessa], 1894–1908. Odessa, 1908. 8vo. VI. 84, 244, 104 pp., 2 plates.[1]

[1] Page finale des journeaux "Revue météorologique" (Travaux du réseau météorologique du sud-ouest de la Russie, 1887–1908) et "Annales" de l'observatoire météorologique et magnétique de l'université impériale à Odessa, fondés par A. Klossovsky. Odessa. 1908. v p. 8°. (Russian text.)

As professor of physical geography in the University of Odessa, as organizer of a network of meteorological stations thruout southwestern Russia, and as director of the magnetic and meteorological observatory at Malyī-Fontàn, near Odessa, Dr. A. Klossovskiĭ has done valiant service in his chosen science. The present volume forms a worthy conclusion of his long-continued and efficient labors. In addition to a modest account by Professor Klossovskiĭ of the rise and progress of the institutions under his charge, it contains a large amount of valuable material for the meteorology of southwestern Russia and a number of special scientific papers by some of his assistants. Among these may be mentioned; Tochidlovskiĭ, On the formation of nuclei in fogs; Ignatiev, On the use of kites in meteorology; Obolenskiĭ, On the theory of the rainbow and of halos; and Aganin, A preliminary paper on gravity determinations at Odessa.

In view of the well known strong perturbation in the earth's magnetic field in the vicinity of Odessa it is of interest to know that careful gravity determinations are in progress.

It is certainly a matter of regret that the two journals created by Professor Klossovskiĭ will not be continued. And it would be still more to be lamented if Professor Klossovskiĭ can not find some means of continuing and completing his work on meteorology of which the first volume[2] (of 642 pp., with numerous illustrations and a map) appeared in 1907. It is to be hoped that now, in his retirement from active service, the author may find leisure to complete this great work which was planned to comprise three more volumes.

THE WEATHER OF THE MONTH.

By Mr. P. C. Day, Acting Chief, Climatological Division.

PRESSURE AND WINDS.

The distribution of the mean atmospheric pressure for January, 1909, over the United States and Canada, is graphically shown on Chart VI, and the average values and departures from the normal are shown for each station in Tables I and III.

The mean atmospheric pressure for the month showed marked departures from normal conditions, the most important of which was an unusual depression over the central and northern portions of the Plateau and Pacific coast districts, where the average pressure ranged from .15 to .25 inch below the normal. It was also below the normal over practically all the remaining districts west of the Rocky Mountains, including the southern portions of British Columbia. East of the Rocky Mountains the average pressure for the month was above the normal in all districts of the United States and Canada, except over extreme southern Florida; the excess over the districts from the Lake region eastward ranging from .05 to .10 inch.

Many of the high pressure areas of the month appear to have had their origin in northern British Columbia west of the Main Divide instead of over the Great Plains to the east of the mountains, their usual point of origin. With pressure unusually low over the Plateau and Pacific coast districts, especially during the first half of the month, cold northerly winds from the high areas over northern British Columbia dominated the weather over the extreme northern portions of the United States from the Rocky Mountains to the Pacific.

Over the districts between the Rocky and Appalachian mountains the prevailing winds were mostly south, while along the Atlantic coast and over the east Gulf States they were generally from some northerly point. Much stormy weather, with cold, high northerly winds prevailed over the north Pacific and northern Plateau districts during the first half of the month.

TEMPERATURE.

January, 1909, was marked by unusual variations in temperature, decided excesses persisting in some localities and deficiencies of equal persistence occurring in others. During the first decade of the month remarkably cold weather prevailed over a restricted area from the Great Lakes westward to the Pacific, being most pronounced over the upper Missouri Valley and the northern portions of the Rocky Mountain, Plateau and Pacific coast districts, where the daily means ranged from 15° to 25° below the average. Minimum temperatures during portions of the above period were unusually low over the States from North Dakota to Washington, ranging from 20° to more than 50° below zero and exceeding in severity any previous record of cold weather for the same period at numerous points, especially in portions of eastern Washington and northern Oregon.

During this decade some unusually warm weather occurred over the districts from the Texas coast to the middle Plateau region and generally over the Southwest, where the mean temperature for the period ranged from 8° to 12° above the normal, and it was also above the normal over all eastern districts.

The second decade was marked by comparatively moderate temperatures over all districts, except over the States from Montana to Washington where extremely cold weather continued until about the 15th. The mean temperature was generally above the normal over the central and southern portions of the Rocky Mountain, Plateau, and Pacific coast districts, and also over most of the Atlantic and Gulf coast districts during the entire period.

During the third decade unusually warm weather was prevalent over all districts until about the 27th, when a severe storm developed over the Great Plains region and moved eastward during the last few days of the month, bringing the severest weather of the season to the districts from the lower Missouri Valley eastward over portions of the Lake region, Ohio Valley, and New England. Unusually warm weather prevailed from the 22d to the 25th over practically all districts from the middle and southern slope regions eastward to the Atlantic; the maximum temperatures during that period at numerous points equalled or exceeded any previous January record.

As a whole, the mean temperature for the month was above the normal over all districts, except a narrow strip along the northern border from central North Dakota westward to the Pacific. Over large portions of the Lake region, Ohio Valley, the Middle and South Atlantic, and Gulf States the average ranged from 5° to 7° above the normal, and over the region from the Texas coast northwestward to southern Idaho and eastern Oregon the average temperature ranged from 6° to 9° daily above the normal.

The remarkably restricted and persistent area of cold that prevailed over the northern portions of the States from North Dakota to Washington during the first half of the month carried the mean temperature for the section from 3° to 8° below the normal, despite the fact that the latter part of the month was unusually warm.

Maximum temperatures of 80°, or slightly higher, occurred from central Kansas southward over Texas, and in Georgia and Florida.

Minimum temperatures of 32° or lower extended to central Florida, central Arizona, and to nearly all districts in Cali-

[2] Klossovskiĭ, A[leksandr]. Meteorologiia. (Obshchiĭ kurs.) Chast I. Staticheskaia meteorologiia. [Meteorology. (General course.) Vol. I. Static meteorology.] Odessa. 1908. A long and appreciative review of this volume appears in Petermann's Mitteilungen, Jan., 1909, Literaturbericht' p. 17-19. If completed as planned, this will be the most extensive treatise on meteorology in any language.—*C. F. T.*

fornia, except the extreme southern part and along the immediate coast. Over the interior of New England they were from 10° to 20° below zero, and over the districts from the upper Lakes westward to central Washington they ranged from 10° to 40° below zero, and at exposed points in Montana they were more than 50° below zero.

PRECIPITATION.

The most marked feature of the distribution of precipitation during the month was the generally heavy amounts received over the Pacific coast States, especially in California, where it was probably one of the rainiests months experienced since the settlement of that State. The average for the entire State, about 16 inches, is more than 10 inches above the normal January fall. The total monthly amounts, including melted snow, at numerous stations in the State, exceeded 50 inches, several stations reported more than 60 inches, and one station reported a total of 71.54 inches, an amount which probably exceeds any monthly precipitation previously reported from any point in the United States.

The month was an unusually rainy one along the entire Pacific coast, rain falling almost daily in the districts west of and including the Sierra and Cascade ranges of mountains.

Precipitation was also generally in excess of the normal over the greater part of the Plateau and Rocky Mountain districts, the amounts over portions of the Main Divide from northwestern Colorado to central Idaho exceeding the normal from 2 to 4 inches. There was also a small excess of precipitation over the upper Mississippi Valley, the greater part of the Lake region, the upper Ohio Valley, New York, and New England.

Over the Great Plains from central Nebraska southward to Texas and eastward over the middle and lower Mississippi and lower Ohio valleys and Gulf States to the Atlantic coast there was a general deficiency in precipitation, being most pronounced from central Texas eastward over the Gulf and South Atlantic States, where the monthly amounts were from 2 to 4 inches less than the normal.

At the end of the month the need of rain was being felt over most of Florida, in many portions of Texas, and at other points in the Gulf States.

The excessive amounts of rain, together with the melting snows, on the watersheds of the Sacramento and San Joaquin rivers of California caused phenomenally high waters in these rivers and much damage resulted. Heavy rains and melting snows also caused floods of considerable proportions in the rivers and smaller streams of the western portions of Oregon and Washington.

SNOWFALL.

Snow in measurable quantities occurred in all portions of the United States, except along the immediate south Atlantic and Gulf coasts, and over the lower elevations of Arizona and southern California. Remarkably heavy snows occurred during the early part of the month over the northern portions of the Rocky Mountain, Plateau, and Pacific coast districts, the amounts that fell on the lower levels and in the valleys of western Washington and Oregon were much in excess of the usual fall, and on account of the prevailing cold weather, remained on the ground for an unusual length of time. Snowfall was heavy in nearly all other portions of the mountain districts of the west, and altho much of it melted under the influence of the prevailing warm weather and frequent rainfalls much still remained on the ground in the higher levels at the end of the month. It was generally well packed, hard frozen, and with a large water content, thus indicating a plentiful supply of water for irrigation purposes during the coming season.

A severe snowstorm and blizzard prevailed in the lower Missouri and middle Mississippi valleys during the 28th and 29th. Winds of almost hurricane velocity prevailed, and with the intense cold and drifting snow, much suffering and loss occurred to unprotected live stock, buildings were damaged, electrical communication seriously interfered with, and transportation much delayed, and in some cases completely abandoned.

At the end of the month the ground was generally well covered with snow from the Missouri Valley eastward over the middle and upper Mississippi Valley, Lake region, Ohio Valley, the northern portions of the Middle Atlantic States, and New England, with maximum depths ranging from 10 to 30 inches over northern New York and the interior of New England and at a few points in Michigan and the upper Lake region. In the mountains of the West the greatest amounts were reported from the Sierras of California, where depths from 10 to 15 feet were reported. In the main ranges of the Rocky Mountains the depths were from 10 to 50 inches at moderate elevations, with doubtless much greater depths in the higher mountains.

HUMIDITY AND SUNSHINE.

Relative humidity was above the normal in all portions of the United States, except over the Lake region and at points in the Plateau and southern Rocky Mountain districts. The average for the month was generally high in the upper Mississippi and Missouri valleys and the central and southern Pacific coast districts, the percentages in portions of California averaging from 5 to 15 above the normal. In portions of western Texas and the southern Rocky Mountain district the percentage ranged from 5 to 10 below the normal.

The month was one of general excess of cloudy weather, all portions of the country reporting the amount of sunshine as below the normal, except at a few points in the south Atlantic and Gulf States and generally over the Florida Peninsula, where the sunshine was normal or slightly above. Over large portions of the Ohio and middle Mississippi valleys, Lake region, and New England the amount of sunshine ranged from 30 to less than 20 per cent of the possible, and over the greater portion of the Pacific slope the amount was less than 20 per cent of the possible. At scattered points along the Atlantic and Gulf coasts and over the Florida Peninsula the amount of sunshine was slightly above 50 per cent of the possible, and in western Texas and portions of Arizona it ranged from 70 to 80 per cent.

Average temperatures and departures from the normal.

Districts.	Number of stations.	Average temperatures for the current month.	Departures for the current month.	Accumulated departures since January 1.	Average departures since January 1.
		°	°	°	°
New England	12	26.9	+ 2.5	....	....
Middle Atlantic	16	35.8	+ 4.0	....	....
South Atlantic	10	50.2	+ 5.0	....	....
Florida Peninsula *	8	64.3	+ 5.4	....	....
East Gulf	11	52.5	+ 5.1	....	....
West Gulf	10	50.4	+ 4.9	....	....
Ohio Valley and Tennessee	13	33.6	+ 4.5	....	....
Lower Lake	10	28.3	+ 4.2	....	....
Upper Lake	12	21.4	+ 3.8	....	....
North Dakota *	9	3.3	− 1.4	....	....
Upper Mississippi Valley	15	24.9	+ 3.4	....	....
Missouri Valley	12	23.8	+ 2.7	....	....
Northern Slope	9	18.3	− 0.7	....	....
Middle Slope	6	32.5	+ 3.5	....	....
Southern Slope *	7	44.2	+ 4.3	....	....
Southern Plateau *	12	44.2	+ 4.8	....	....
Middle Plateau *	10	31.2	+ 6.4	....	....
Northern Plateau *	12	24.9	− 2.3	....	....
North Pacific	7	35.2	− 4.3	....	....
Middle Pacific	8	50.4	+ 3.3	....	....
South Pacific	4	53.4	+ 2.5	....	....

* Regular Weather Bureau and selected cooperative stations.

In Canada.—Director R. F. Stupart says:

The first part of the month was marked by extremely cold weather in the Western Provinces and British Columbia, and the monthly mean

temperature in that portion of Canada was from 1° to 15° below the average, the difference increasing westward from Manitoba. In Ontario, on the other hand, there was much unseasonably mild weather, as is evidenced by mean temperatures of from 2° to 6° above normal. More seasonable temperature conditions prevailed in Quebec and the Maritime Provinces, and the mean temperature there was in the close neighborhood of the normal value.

The precipitation was less than average over the greater portion of Canada, but in the St. Lawrence Valley and in New Brunswick it was somewhat in excess. The most marked feature, however, was the unusual snowfall in British Columbia, where even near the coast there was sleighing on several days and the higher levels were soon thickly covered. At the close of the month in the Western Provinces the depth varied from a trace in southern Alberta to 8 inches at Edmonton, 14 inches at Prince Albert, and about 6 inches over the most of Manitoba. Ontario was snow covered, the depth ranging from about 2 inches in the south to 27 inches in the Ottawa Valley, and 21 inches in New Ontario. Quebec and northern New Brunswick were buried under a depth of from 20 to 48 inches of snow, while the Maritime Provinces showed a white mantle varying from 5 to 28 inches in depth.

Average precipitation and departures from the normal.

Districts.	Number of stations.	Average.		Departure.	
		Current month.	Percentage of normal.	Current month.	Accumulated since Jan. 1.
		Inches.		*Inches.*	*Inches.*
New England	12	3.58	113	+ 0.4	....
Middle Atlantic	16	2.57	79	— 0.7	....
South Atlantic	10	1.63	44	— 2.1	....
Florida Peninsula*	8	2.07	72	— 0.8	....
East Gulf	11	1.85	37	— 3.1	....
West Gulf	10	0.39	13	— 2.6	....
Ohio Valley and Tennessee	13	2.86	74	— 1.0	....
Lower Lake	10	2.93	111	+ 0.3	....
Upper Lake	12	1.59	80	— 0.4	....
North Dakota*	9	0.42	68	— 0.2	....
Upper Mississippi Valley	15	1.86	106	+ 0.1	....
Missouri Valley	12	0.95	100	0.0	....
Northern Slope	9	0.82	100	0.0	....
Middle Slope	6	0.22	35	— 0.4	....
Southern Slope*	7	0.11	11	— 0.9	....
Southern Plateau*	12	0.95	100	0.0	....
Middle Plateau*	10	2.10	105	+ 1.0	....
Northern Plateau*	12	2.70	169	+ 1.1	....
North Pacific	7	8.66	126	+ 1.8	....
Middle Pacific	8	11.36	255	+ 6.9	....
South Pacific	4	8.07	291	+ 5.3	....

* Regular Weather Bureau and selected cooperative stations.

Average relative humidity and departures from the normal.

Districts.	Average.	Departure from the normal.	Districts.	Average.	Departure from the normal.
New England	77	+ 1	Missouri Valley	80	+ 5
Middle Atlantic	77	+ 1	Northern Slope	75	+ 3
South Atlantic	80	+ 3	Middle Slope	69	+ 2
Florida Peninsula	83	+ 2	Southern Slope	50	—10
East Gulf	78	0	Southern Plateau	59	+ 5
West Gulf	78	+ 2	Middle Plateau	72	— 1
Ohio Valley and Tennessee	80	+ 3	Northern Plateau	76	— 3
Lower Lake	80	— 1	North Pacific	86	+ 1
Upper Lake	81	— 2	Middle Pacific	88	+ 5
North Dakota	88	+ 5	South Pacific	85	+ 13
Upper Mississippi Valley	83	+ 5			

Average cloudiness and departures from the normal.

Districts.	Average.	Departure from the normal.	Districts.	Average.	Departure from the normal.
New England	7.1	+ 1.3	Missouri Valley	6.5	+ 1.4
Middle Atlantic	6.6	+ 1.0	Northern Slope	5.7	+ 1.1
South Atlantic	5.6	+ 0.3	Middle Slope	5.8	+ 2.0
Florida Peninsula	4.6	— 0.1	Southern Slope	4.8	+ 1.0
East Gulf	5.6	0.0	Southern Plateau	4.4	+ 1.5
West Gulf	6.5	+ 1.1	Middle Plateau	6.4	+ 1.6
Ohio Valley and Tennessee	8.0	+ 1.6	Northern Plateau	7.6	+ 0.3
Lower Lake	7.9	+ 0.4	North Pacific	8.4	+ 1.3
Upper Lake	7.1	+ 0.3	Middle Pacific	8.1	+ 3.0
North Dakota	5.3	+ 0.6	South Pacific	7.6	+ 3.5
Upper Mississippi Valley	7.3	+ 2.0			

Maximum wind velocities.

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
Amarillo, Tex	28	64	w.	North Head, Wash	31	50	se.
Atlanta, Ga	29	60	nw.	North Platte, Nebr	28	58	nw.
Do	30	58	nw.	Oklahoma, Okla	28	64	w.
Bismarck, N. Dak	28	52	nw.	Do	29	66	nw.
Block Island, R. I	7	52	nw.	Omaha, Nebr	28	66	nw.
Do	17	50	e.	Do	29	60	nw.
Do	26	54	nw.	Pierre, S. Dak	28	61	nw.
Do	28	55	nw.	Do	29	51	nw.
Do	29	53	e.	Point Reyes Light, Cal	1	52	s.
Buffalo, N. Y	19	60	sw.	Do	2	54	s.
Do	25	52	sw.	Do	5	53	s.
Do	27	52	sw.	Do	7	60	s.
Burlington, Vt	19	54	s.	Do	8	62	s.
Cairo, Ill	29	56	w.	Do	13	51	sw.
Cape Henry, Va	28	58	nw.	Do	14	60	s.
Columbia, Mo	29	60	nw.	Do	15	54	s.
Detroit, Mich	29	50	e.	Do	20	66	s.
Duluth, Minn	6	54	nw.	Do	21	54	s.
Do	29	71	nw.	Do	22	54	nw.
Do	30	59	nw.	Do	23	51	s.
Eastport, Me	6	60	s.	Do	24	65	s.
Do	30	54	ne.	Do	25	71	s.
Fort Smith, Ark	28	64	w.	Do	29	52	s.
Galveston, Tex	29	50	nw.	Do	30	62	s.
Huron, S. Dak	28	56	n.	Reno, Nev	30	52	sw.
Jacksonville, Fla	29	56	sw.	St. Louis, Mo	30	52	nw.
Kansas City, Mo	28	63	nw.	St. Paul, Minn	29	54	n.
Do	29	74	nw.	Sand Key, Fla	5	55	nw.
Key West, Fla	5	58	w.	Sault Ste. Marie, Mich	25	52	w.
Lincoln, Nebr	28	72	nw.	Sioux City, Iowa	29	72	nw.
Do	29	62	nw.	Southeast Farallon, Cal	20	50	s.
Little Rock, Ark	29	56	nw.	Do	24	51	s.
Memphis, Tenn	28	54	sw.	Do	25	56	se.
Do	29	64	w.	Springfield, Mo	28	59	sw.
Minneapolis, Minn	29	53	n.	Tatoosh Island, Wash	1	58	e.
Mount Tamalpais, Cal	3	50	sw.	Do	4	57	ne.
Do	8	54	sw.	Do	5	76	e.
Do	9	58	nw.	Do	6	66	e.
Do	12	57	sw.	Do	7	75	e.
Do	13	56	sw.	Do	8	64	e.
Do	14	50	sw.	Do	9	63	e.
Do	20	66	sw.	Do	10	64	e.
Do	21	54	w.	Do	14	60	e.
Mount Weather, Va	12	58	nw.	Do	15	58	s.
Do	28	59	nw.	Do	16	72	s.
Do	30	64	nw.	Do	17	50	s.
Do	31	69	nw.	Do	18	54	sw.
New York, N. Y	27	54	w.	Do	19	62	s.
Do	28	57	nw.	Do	27	56	w.
North Head, Wash	2	62	se.	Do	28	67	e.
Do	14	56	s.	Do	29	58	e.
Do	15	84	se.	Topeka, Kans	28	52	nw.
Do	16	73	se.	Do	29	58	w.
Do	17	72	se.	Valentine, Nebr	28	56	nw.
Do	18	70	se.	Wichita, Kans	28	60	nw.
Do	19	76	se.	Do	29	62	nw.
Do	27	66	nw.	Yankton, S Dak	28	55	nw.
Do	30	60	se.	Do	29	58	nw.

CLIMATOLOGICAL SUMMARY.

By Mr. P. C. DAY, Assistant Chief, Climatological Division.

TEMPERATURE AND PRECIPITATION BY SECTIONS, JANUARY 1909.

In the following table are given, for the various sections of the Climatological Service of the Weather Bureau, the average temperature and rainfall, the stations reporting the highest and lowest temperatures with dates of occurrence, the stations reporting greatest and least monthly precipitation, and other data, as indicated by the several headings.

The mean temperatures for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperature and precipitation are based only on records from stations that have ten or more years of observation. Of course the number of such records is smaller than the total number of stations.

Section.	Temperature—in degrees Fahrenheit.								Precipitation—in inches and hundredths.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
Alabama	50.0	+ 5.6	3 stations	82	25	Valley head	3	31	2.16	− 2.58	Cullman	4.74	Goodwater, Troy	0.34
Arizona	49.1	+ 4.3	Aztec	90	7	Flagstaff	6	26	0.92	− 0.23	Pinal Ranch	3.44	3 stations	0.00
Arkansas	43.8	+ 3.7	Pine Bluff Prescott	82 82	25 23	Pond	−19	12	1.79	− 2.15	Pocahontas	3.62	Springbank	0.36
California	47.8	+ 3.0	Rialto (near)	84	18	Alturas	−21	10	16.17	+10.17	Helen Mine	71.54	3 stations	0.00
Colorado	27.8	+ 4.3	Hoehne	83	9, 28	Gunnison, Kremmling.	−38	30	1.21	+ 0.23	Marble	3.37	Ft. Morgan, Holyoke	0.00
Florida	62.4	+ 4.8	Merritts Island	89	4	Marianna	18	31	1.67	− 1.36	Jupiter	5.98	Macclenny	0.34
Georgia	50.9	+ 6.4	Quitman	87	24	Dahlonega, Diamond	5	31	1.96	− 1.97	Clayton	4.92	Statesboro	0.21
Hawaii (December, 1908)	68.5*	......	Kihei, Maui	95	7	Humuula, Hawaii	31	27	7.33†	......	Hakalau, Mauka, Hawaii.	33.15	4 stations	0.00
Idaho	27.8	+ 2.6	Emmett	63	16	Chesterfield Spirit Lake	−28 −28	29 11	4.07	+ 1.76	Landore	12.61	Camas	0.47
Illinois	29.2	+ 2.8	Benton	78	24, 25	Lanark, Zion	−20	6	2.31	− 0.14	Du Quoin	5.80	Ottawa	0.98
Indiana	31.9	+ 4.1	Farmersburg	73	23	Salamonia	−15	13	2.67	− 0.23	Knox	5.01	Eminence	1.48
Iowa	21.2	+ 1.9	Keokuk	72	23	3 stations	−25	6	1.66	+ 0.61	Ridgeway	3.74	Le Mars	0.41
Kansas	29.8	+ 0.3	Liberal	80	9	Coolidge	−20	11	0.49	− 0.23	Paola	1.59	Coolidge, Hugoton	0.00
Kentucky	38.4	+ 3.2	Cattlettsburg	77	22	Hopkinsville	− 8	31	3.47	− 0.54	Williamsburg	6.65	Owenton	2.23
Louisiana	54.8	+ 4.5	Ferriday	87	24	Minden	16	31	1.96	− 2.47	Donaldsonville	4.21	Sugartown	0.24
Maryland and Delaware	35.3	+ 3.0	Millsboro, Del	71	24	Oakland, Md	− 3	19	2.75	− 0.30	Dover, Del	3.58	Westernport, Md	1.48
Michigan	23.7	+ 3.3	South Haven	66	3 d't's	Humboldt	−38	12	1.97	− 0.11	Muskegon	3.56	Humboldt	0.17
Minnesota	10.5	+ 1.1	3 stations	49	3 d't's	International Falls	−55	6	1.32	+ 0.58	Windom	2.72	Hallock	0.38
Mississippi	49.8	+ 3.6	Greenwood	83	24	3 stations	10	31	2.22	− 2.59	Woodville	4.67	Anguilla	0.65
Missouri	33.7	+ 2.5	Fulton	83	23	Warsaw	−20	12	2.17	− 0.27	Greenville	5.24	Conception	0.42
Montana	13.9	− 6.0	Steele	63	27	Chester	−55	11	1.72	+ 0.54	Snowshoe	15.48	Norris	0.05
Nebraska	23.0	− 0.6	Alma	67	3	Fort Robinson	−32	12	0.41	− 0.09	Weepingwater	2.16	7 stations	0.00
Nevada	35.6	+ 6.3	Las Vegas	77	17	Ely	−16	11	2.47	+ 1.09	Lewis Ranch	21.55	Jean	0.09
New England ‡	24.5	+ 2.7	Monson, Mass Torrington, Conn	67 67	5 23	Bloomfield, Vt	−32	19	4.23	+ 0.77	Bar Harbor, Me	7.10	Durham, N. H	1.93
New Jersey	33.2	+ 3.2	Indian Mills	69	23	Layton	−12	19	3.18	− 0.42	Belvidere	4.13	Canton	2.18
New Mexico	41.6	+ 6.1	Carlsbad	84	9	Elizabethtown Vermejo Park	−17 −17	12 12	0.26	− 0.37	Manuelito	1.83	8 stations	0.00
New York	25.3	+ 3.4	Avon; other stations	64	24	Indian Lake	−35	13	3.35	+ 0.44	Adams Center	7.38	Lyndonville	0.85
North Carolina	45.7	+ 5.6	Moncure Whiteville	84 84	25 25	Banners Elk	− 5	31	2.19	− 1.67	Horse Cove	5.72	Fayetteville	0.96
North Dakota	3.5	− 2.1	Oriska	53	22	Dunseith	−48	11	0.42	− 0.10	Lakota	1.45	Grafton	0.00
Ohio	32.2	+ 4.4	Ironton	74	24	Bladensburg, Rome	−17	13	3.24	+ 0.47	Summerfield	5.88	New Bremen	1.96
Oklahoma	39.6	+ 1.4	Healdton	88	4	Vinita	−15	12	0.35	− 1.04	Vinita	1.80	3 stations	0.00
Oregon	31.9	− 3.5	Vale	80	7	Warmspring	−32	12	8.40	+ 3.66	Buckhorn Farm	29.16	Blalock	1.20
Pennsylvania	31.2	+ 3.4	California	72	21	Seagerstown	−19	13	2.92	− 0.40	Skidmore	4.25	Pocono Lake	1.58
Porto Rico	72.6	− 0.7	3 stations	92	18, 31	Aibonto	48	17	3.19	− 0.30	Sabana Grande	6.21	Coloso	0.21
South Carolina	49.6	+ 5.2	Blackville Waterboro	83 83	24 25	Heath Springs	9	31	1.54	− 2.09	Clemson College	4.74	Ferguson	0.50
South Dakota	14.4	− 1.3	Fort Meade	66	28	Cascade Springs	−41	11	0.58	+ 0.12	Ardmore	1.60	Spearfish	T.
Tennessee	42.8	+ 4.8	4 stations	76	23, 25	Sewanee	− 1	31	2.94	− 1.96	Rugby	5.23	Center Point	1.10
Texas	52.4	+ 4.8	Fort McIntosh Zapata	92 92	28 28	Plemons	−10	12	0.15	− 1.74	Arthur City Clarksville	1.24 1.24	15 stations	0.00
Utah	31.9	+ 5.0	St. George	68	6, 28, 31	Schofield	−32	29	2.88	+ 1.58	Schofield	18.38	Green River	0.05
Virginia	40.0	+ 4.7	Lynchburg	77	24	Burkes Garden	− 4	31	2.49	− 0.64	Big Stone Gap	5.26	Sabot	0.08
Washington	25.9	− 7.0	Mottingers Ranch Walla Walla	62 62	19 19	Northport Republic	−32 −32	11 11	5.92	+ 0.94	Forks	24.62	Kennewick	0.99
West Virginia	36.8	+ 4.9	Charleston	76	24	North Cumberland	− 5	13	3.41	− 0.06	Smithfield	6.59	Elkhorn	1.50
Wisconsin	17.7	+ 2.6	Ashland	58	23	Merrill	−48	12	1.19	− 0.11	Broadhead	2.93	Antigo	0.25
Wyoming	22.5	+ 2.0	Pine Bluff	69	20, 22	Daniel	−40	11	1.33	+ 0.62	Bedford	6.06	Pine Bluff	T

*52 stations; average elevation, 734 feet. † Average of 147 stations. ‡ Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut.

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DESCRIPTION OF TABLES AND CHARTS.

By Mr. P. C. DAY, Assistant Chief, Climatological Division.

Table I gives the data ordinarily needed for climatological studies for about 157 Weather Bureau stations making simultaneous observations at 8 a. m. and 8 p. m., seventy-fifth meridian time daily, and for about 37 others making only one observation. The altitudes of the instruments above ground are also given.

Table II gives a record of precipitation the intensity of which equaled or exceeded the following rates:

Duration, minutes	5	10	15	20	25	30	35	40	45	50	60
Rates per hour (inches)	3.00	1.80	1.40	1.20	1.08	1.00	0.94	0.90	0.87	0.84	0.80

In cases where no precipitation of sufficient intensity to entitle it to a place in the full table has occurred, the greatest single precipitation has been given, also the greatest hourly fall.

Table III gives, for about 30 stations of the Canadian Meteorological Service, the means of pressure and temperature, total precipitation and depth of snowfall, and the respective departures from normal values, except in the case of snowfall.

Table IV gives the heights of rivers referred to zeros of gages. These zeros are arbitrarily fixt, but, as a rule, are set at the plane of lowest water, if possible. The river gages are read once daily (8 a. m., seventy-fifth meridian time), and in times of emergency more frequently. The table shows the highest and lowest of all readings taken, the means of the regular daily readings, and the absolute monthly ranges.

The publication of the data from cooperative observers, heretofore appearing as Table II, was discontinued with the issue for December, 1907. The values will continue to be published in the monthly reports of the climatological services of the several States, and in the usual manner in the quarto Annual Report of the Chief of the Weather Bureau and are used in compiling charts IV, VII, and VIII.

Chart I.—Hydrographs for seven principal rivers of the United States.

Chart II, tracks of centers of high areas, and Chart III, tracks of centers of low areas. The roman numerals show number and chronological order of the centers. The figures within the circles show the days of the month; the letters *a* and *p* indicate, respectively, the positions at 8 a. m. and 8 p. m., seventy-fifth meridian time. Within each circle is also given (Chart II) the highest barometric reading and (Chart III) the lowest reading reported at or near the center at that time, and in both cases as reduced to sea level and standard gravity.

Chart IV.—Total precipitation. This chart is based on all reports from regular and cooperative observers. The scale of shades showing the amount is given on the chart. Where the monthly amounts are too small to justify shading, and over sections of the country where the stations are too widely separated or the topography is too diversified to warrant reasonable accuracy in shading, the actual amounts are given for a limited number of representative stations. Amounts less than 0.005 inch are indicated by the letter "T," and no precipitation by 0.

Chart V.—Percentage of clear sky between sunrise and sunset. The average cloudiness at each Weather Bureau station is determined by numerous personal observations between sunrise and sunset. The difference between the observed cloudiness and 100 is assumed to represent the percentage of clear sky, and the values thus obtained are the basis of this chart which does not relate to the nighttime.

The monthly totals of hours and the percentages of possible sunshine as taken from records by Marvin's thermometric sunshine recorder, will be found in Part VI of the quarto Annual Report of the Chief of the Weather Bureau for the current year.

Chart VI.—Isobars and isotherms at sea-level and prevailing wind directions. The pressures have been reduced to sea level and standard gravity by the method described by Prof. Frank H. Bigelow on pages 13-16 of the MONTHLY WEATHER REVIEW for January, 1902. The pressures have also been reduced to the mean of the twenty-four hours by the application of a suitable correction to the mean of the 8 a. m. and 8 p. m. readings, at stations taking two observations daily, and to the 8 a. m. or 8 p. m. observation, respectively, at stations taking but a single observation. The diurnal corrections so applied will be found in Annual Report of the Chief of the Weather Bureau, 1900-1901, Volume II, Table 27, pp. 140-164.

The isotherms on the sea-level plane have been constructed by means of the data summarized in the Annual Report of the Chief of the Weather Bureau for 1900-1901, Volume II, chapter 8, Table 48, pp. 640-771. The correction $t_0 - t$, or temperature on the sea-level plane minus the station temperature, as given by Table 48 of the above report, is added to the observed surface temperature to obtain the adopted sea-level temperature.

The prevailing wind directions are determined from the continuous records for the month at the great majority of the stations; a few stations, having no self-recording wind direction apparatus, determine the prevailing direction from the daily or twice-daily observations.

Chart VII.—Total snowfall. This Chart is based on the reports from regular and cooperative observers, and shows the depth in inches and tenths of the snowfall during the month. In general, the depth is shown by lines inclosing areas of equal snowfall, but in special cases figures are also given.

Chart VIII.—Depth of snow on ground at the end of month, exprest in inches and tenths.

TABLE I.—*Climatological data for U. S. Weather Bureau stations, January, 1909.*

Stations.	Elevation of instruments: Barometer above sea level, feet.	Thermometers above ground.	Anemometer above ground.	Pressure, in inches: Actual, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hrs.	Departure from normal.	Temperature of the air, in degrees Fahrenheit: Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Precipitation, in inches: Total.	Departure from normal.	Days with .01, or more.	Wind: Total movement, miles.	Prevailing direction.	Maximum velocity: Miles per hour.	Direction.	Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness during daylight, tenths.	Total snowfall.
New England.							26.9	+ 2.5										77	3.58	+ 0.4										7.1	
Eastport	76	67	85	30.00	30.09	+ .09	21.6	+ 1.5	52	6	30	- 6	16	13	47	20	16	79	7.09	+ 3.2	16	11,541	w.	60	s.	6	7	6	18	7.3	26.0
Greenville	1,070	6	....	29.88	30.11	......	13.0	......	46	6	23	-21	17	3	41				4.51	......	12										
Portland, Me.	103	81	117	29.99	30.12	+ .07	23.0	+ 1.0	54	6	31	- 4	19	15	32	20	16	74	4.71	+ 0.9	11	8,300	nw.	35	nw.	28	8	9	14	6.5	32.3
Concord	288	70	79	29.80	30.14	+ .09	23.5	+ 2.3	55	6	32	-11	19	15	36				2.98	- 0.4	11	4,055	nw.	30	nw.	28	10	5	16	6.3	18.6
Burlington	404	12	47	29.67	30.14	+ .09	18.6	+ 2.3	46	5	28	-18	19	9	39	....	....	....	2.38	+ 0.6	14	11,016	s.	54	s.	19	6	8	17	7.2	18.4
Northfield	876	16	70	29.14	30.14	+ .09	18.3	+ 3.2	50	11	29	-26	19	7	54	17	15	87	3.55	+ 1.1	17	7,658	s.	41	nw.	28	1	13	17	7.8	37.0
Boston	125	115	188	29.98	30.12	+ .07	30.8	+ 3.3	60	5	38	3	19	22	32	28	23	74	3.94	+ 0.1	14	8,742	w.	39	nw.	26	2	10	19	7.6	11.2
Nantucket	12	14	90	30.07	30.08	+ .04	34.8	+ 2.7	53	6	41	20	18	29	24	33	29	81	4.54	+ 1.1	16	12,831	nw.	48	sw.	6	6	5	20	7.7	5.9
Block Island	26	11	46	30.08	30.11	+ .04	33.2	+ 1.8	56	6	39	11	19	28	29	31	27	77	3.95	+ 0.1	14	15,046	nw.	55	nw.	28	7	4	20	7.1	6.2
Narragansett	.....	9	....	......	......	......	30.6	+ 2.2	57	6	39	3	19	22	33	....	....	....	5.07	......	15	......	nw.	....	....	....	10	5	16	....	8.5
Providence	160	141	165	29.95	30.14	+ .08	29.6	+ 2.4	59	5	38	3	19	22	33	27	22	74	3.06	- 0.8	16	8,113	n.	41	nw.	26	4	10	17	7.1	10.4
Hartford	159	122	140	29.96	30.14	+ .07	29.0	+ 3.5	56	22	37	- 2	19	21	32	26	21	75	2.80	- 1.0	15	6,319	n.	32	nw.	26	4	8	19	7.7	9.4
New Haven	106	116	155	30.00	30.12	+ .04	30.7	+ 3.4	58	6	38	1	19	23	34	27	22	73	3.38	- 0.5	16	7,693	ne.	37	nw.	28	10	6	15	6.3	9.6
Mid. Atlantic States.							35.8	+ 4.0										77	2.57	- 0.7										6.6	
Albany	97	102	115	30.05	30.16	+ .09	25.6	+ 3.1	53	6	34	-12	19	18	35	23	19	78	3.00	+ 0.4	16	6,925	s.	31	s.	19	6	7	18	7.1	13.6
Binghamton	871	78	90	29.17	30.13	+ .05	26.8	+ 3.7	56	24	35	-11	19	19	36	....	....	....	2.92	+ 0.9	17	5,022	w.	24	nw.	31	2	2	27	8.6	12.5
New York	314	108	350	29.78	30.14	+ .04	33.2	+ 3.0	57	5	40	7	19	27	27	30	26	75	3.33	- 0.5	11	10,231	nw.	57	nw.	28	6	10	15	6.7	9.5
Harrisburg	374	94	104	29.75	30.17	+ .07	31.2	+ 2.5	55	25	38	5	19	24	29	28	23	74	1.83	- 1.0	12	5,408	e.	36	w.	27	6	10	15	6.7	7.8
Philadelphia	117	116	184	30.04	30.17	+ .06	35.6	+ 3.8	58	5	42	9	19	29	27	32	28	75	2.52	- 0.9	14	8,140	nw.	38	nw.	28	8	10	13	6.3	2.9
Scranton	805	111	119	29.26	30.15	+ .06	29.2	+ 3.7	56	22	37	- 2	19	22	35	26	20	70	2.86	+ 0.1	17	5,400	sw.	34	w.	27	3	5	23	8.4	11.6
Atlantic City	52	37	48	30.08	30.14	+ .03	37.1	+ 4.6	64	24	45	11	19	30	26	34	30	79	3.29	- 0.1	13	6,683	nw.	30	se.	17	7	6	18	6.9	4.5
Cape May	17	48	52	30.15	30.17	+ .05	37.5	+ 3.4	63	24	44	10	19	31	26	35	....	....	2.79	- .06	12	7,283	nw.	36	nw.	28	7	12	12	6.1	4.0
Baltimore	123	100	113	30.04	30.17	+ .05	35.6	+ 2.2	61	25	42	12	19	29	25	32	28	75	2.78	- 0.4	12	5,067	nw.	30	nw.	6	5	6	20	7.3	4.4
Washington	112	59	76	30.04	30.17	+ .04	36.0	+ 3.1	61	25	43	13	19	29	25	32	28	75	2.84	- 0.5	9	5,389	nw.	39	nw.	28	7	8	16	6.7	3.7
Cape Henry	18	9	58	30.12	30.14	+ .01	44.6	+ 4.4	74	24	52	25	31	37	31	....	....	....	1.73	- 1.6	11	10,875	n.	58	nw.	28	15	5	11	4.8	0.5
Lynchburg	681	83	88	29.42	30.19	+ .06	41.2	+ 5.4	77	24	51	15	31	31	36	36	32	76	1.36	- 2.4	8	3,588	nw.	36	nw.	27	9	7	15	6.5	0.1
Mount Weather	1,725	10	54	28.25	30.14	+ .01	33.6	+ 6.3	67	24	42	7	8	26	31	30	26	79	2.84	- 0.5	9	12,739	nw.	69	nw.	31	9	10	12	6.2	5.0
Norfolk	91	102	111	30.06	30.16	+ .03	46.1	+ 5.7	74	24	54	22	31	38	32	41	38	81	1.49	- 1.9	10	7,205	n.	34	nw.	28	11	8	12	5.7	1.0
Richmond	144	145	153	30.02	30.18	+ .05	42.2	+ 4.2	74	24	51	20	7	34	34	....	....	....	3.00	0.0	11	6,183	s.	35	nw.	26	10	6	15	6.0	0.2
Wytheville	2,293	40	47	27.73	30.18	+ .04	38.6	+ 5.6	65	24	48	3	31	30	34	34	32	84	2.53	- 1.8	9	4,408	w.	30	w.	29	12	3	16	5.7	2.4
S. Atlantic States.							50.2	+ 5.0										80	1.63	- 2.1										5.6	
Asheville	2,255	53	75	27.76	30.19	+ .04	42.4	+ 7.0	71	24	52	2	31	33	36	37	35	82	1.58	- 3.1	11	6,846	se.	38	nw.	30	10	9	12	6.2	0.3
Charlotte	773	68	76	29.33	30.19	+ .04	45.2	+ 4.8	75	25	54	14	31	36	28	40	36	76	1.64	- 2.6	9	5,242	ne.	40	sw.	29	7	15	9	5.9	T.
Hatteras	11	12	47	30.13	30.14	.00	50.6	+ 4.8	72	23	57	25	31	44	28	47	45	88	3.05	- 1.9	9	11,192	ne.	44	nw.	30	16	6	9	4.9	
Manteo	.....	....	....	......	......	......	49.2	......	75	25	58	24	31	40	51	....	....	....	3.70	+ 0.9	5	......	n.	....	....	....	17	6	8	....	
Raleigh	376	71	79	29.76	30.18	+ .05	46.0	+ 5.6	76	25	56	16	31	36	29	40	34	72	1.90	- 1.6	10	6,034	ne.	35	nw.	30	9	12	10	5.7	
Wilmington	78	81	91	30.09	30.18	+ .04	50.6	+ 5.0	79	25	60	19	31	42	26	45	41	80	1.06	- 2.4	6	5,819	n.	36	sw.	29	10	12	9	5.0	
Charleston	48	14	92	30.11	30.16	+ .01	53.6	+ 4.3	78	25	61	19	31	46	28	48	45	82	0.61	- 2.8	5	7,574	n.	37	w.	30	9	10	12	5.5	
Columbia, S. C.	351	41	57	29.79	30.18	+ .03	49.2	+ 4.1	79	25	59	15	31	40	32	43	38	73	1.54	- 1.8	5	5,196	ne.	36	w.	30	9	10	12	5.7	
Augusta	180	89	97	29.98	30.18	+ .02	50.2	+ 4.3	77	25	60	16	31	41	34	45	41	79	0.99	- 3.2	6	4,720	ne.	36	w.	29	9	8	14	6.0	
Savannah	65	81	89	30.10	30.17	+ .02	55.0	+ 5.1	80	25	64	19	31	46	24	49	46	82	0.65	- 2.5	4	5,168	ne.	35	w.	30	11	9	11	5.5	
Jacksonville	43	101	129	30.11	30.16	+ .01	59.2	+ 5.3	79	24	67	23	31	51	24	54	53	91	1.17	- 2.0	5	6,548	ne.	56	sw.	29	12	9	10	5.1	
Florida Peninsula.							68.3	+ 4.8										83	2.62	0.0										4.6	
Jupiter	28	10	48	30.08	30.11	+ .01	68.6	+ 4.3	80	26	75	37	31	62	22	63	60	81	5.98	+ 2.4	17	7,876	e.	35	w.	30	10	15	6	5.0	
Key West	22	10	53	30.07	30.09	- .01	71.0	+ 2.2	79	29	76	54	31	66	15	66	64	82	1.82	- 0.2	5	7,044	ne.	58	w.	5	18	7	6	3.8	
Sand Key	25	41	71	30.06	30.09	- .01	71.2	......	78	28	73	58	31	69	10	....	....	....	0.89	- 1.1	6	12,447	ne.	55	nw.	5	15	12	4	4.5	
Tampa	35	79	96	30.10	30.14	+ .02	65.2	+ 7.8	81	24	74	30	31	57	24	59	57	85	1.78	- 1.0	4	5,459	ne.	37	w.	29	10	13	8	5.1	
East Gulf States.							52.5	+ 5.1										78	1.85	- 3.1										5.6	
Atlanta	1,174	190	216	28.92	30.19	+ .04	46.1	+ 3.9	72	25	54	8	31	38	31	42	39	80	1.82	- 3.5	7	9,742	e.	60	nw.	29	11	6	14	5.9	T.
Macon	370	78	87	29.77	30.18	+ .02	50.1	+ 4.5	77	24	59	14	31	42	32	....	....	....	1.54	- 3.6	7	4,771	ne.	32	w.	29	10	8	13	5.7	T.
Thomasville	273	8	58	29.87	30.17	+ .01	57.0	+ 6.0	82	24	68	19	31	46	33	50	46	80	0.51	- 3.6	5	3,934	e.	30	nw.	30	13	9	9	4.8	
Pensacola	56	79	96	30.11	30.17	+ .03	56.6	+ 4.3	76	26	64	22	31	49	27	....	....	....	1.71	- 2.3	6	6,503	ne.	43	nw.	29	11	12	8	4.9	
Anniston	741	9	58	29.40	30.21	+ .05	48.4	+ 6.2	75	25	58	10	31	39	35	....	....	....	2.27	- 3.0	9	5,396	se.	35	w.	29	7	5	19	6.9	T.
Birmingham	700	11	48	29.42	30.21	+ .05	49.4	+ 4.1	76	25	58	11	31	41	33	44	40	76	2.65	- 2.7	10	6,210	se.	36	nw.	29	8	11	12	6.3	T.
Mobile	57	98	106	30.11	30.17	+ .02	56.5	+ 6.7	76	26	66	23	31	48	29	51	47	78	1.50	- 3.4	10	5,500	n.	34	w.	29	16	10	5	4.3	
Montgomery	223	100	112	29.94	30.20	+ .04	52.1	+ 4.4	77	25	62	16	31	43	32	47	43	76	2.13	- 3.0	7	5,301	nw.	35	nw.	30	11	6	14	5.4	
Meridian	375	84	93	29.78	30.19	+ .03	50.8	+ 5.8	76	23	61	16	31	41	35	46	43	79	1.30	- 4.2	7	4,258	n.	38	w	29	11	6	14	5.8	
Vicksburg	247	62	74	29.91	30.20	+ .04	51.6	+ 4.6	77	24	60	20	31	43	32	46	42	74	1.24	- 4.4	9	5,433	e.	44	nw.	29	8	7	16	6.2	
New Orleans	51	88	121	30.11	30.17	+ .04	58.4	+ 5.4	79	23	66	29	31	51	26	53	51	84	3.72	- 0.9	7	6,155	n.	37	nw.	29	8	14	9	5.5	
West Gulf States.							50.4	+ 4.9										78	0.39	- 2.6										6.5	
Shreveport	249	77	84	29.90	30.18	+ .04	51.6	+ 5.4	79	23	60	20	12	43	40	46	43	77	0.63	- 3.8	6	5,906	se.	40	nw.	29	7	7	17	6.4	0.8
Bentonville	1,303	11	44	28.73	30.14	.00	37.6	+ 3.5	73	23	46	- 6	12	30	51	....	....	....	1.57	- 1.1	9	6,317	s.	38	sw.	28	4	4	23	8.2	9.9
Fort Smith	457	79	94	29.65	30.14	.00	42.4	+ 4.1	77	22	50	- 6	12	34	47	38	34	76	0.62	- 1.9	7	7,251	e.	64	w.	28	4	5	22	7.8	3.8
Little Rock	357	139	147	29.78	30.17	+ .02	43.8	+ 3.2	74	23	51	13	12	37	37	40	36	74	0.71	- 4.1	10	7,846	s.	56	nw.	29	4	7	20	7.7	0.4
Brownsville	57	4	....	......	......	......	......	......	....	....	....	....	....	....	....	....	....	....	......	......	....	......	....	....	....	....	....	....	....	....	
Corpus Christi	20	69	77	30.12	30.14	+ .04	59.4	+ 5.9	79	4	66	24	12	53	43	55	51	82	T.	- 2.2	0	9,526	se.	39	s.	21	10	12	9	5.4	T.
Fort Worth	670	106	114	29.43	30.15	+ .03	49.0	+ 4.7	85	22	59	8	12	39	58	....	....	....	0.09	- 2.0	2	9,469	s.	48	nw.	29	8	15	8	5.4	T.
Galveston	54	106	112	30.12	30.18	+ .03	57.8	+ 5.1	74	26	63	28	12	52	34	56	54	91	0.02	- 3.6	2	8,188	se.	50	nw.	29	14	8	9	4.9	
Palestine	510	73	79	29.61	30.15	+ .03	52.0	+ 5.5	80	22	61	14	12	44	43	47	43	78	0.19	- 3.7	3	6,817	s.	37	s.	28	0	12	19	8.0	0.1
San Antonio	701	80	91	29.38	30.12	+ .02	57.2	+ 6.1	83	23	67	20	12	47	35	49	43	68	0.10	- 1.6	1	5,791	se.	42	n.	29	8	14	9	5.7	T.
Taylor	583	55	63	29.54	30.16	+ .05	53.0	+ 5.5	82	23	63	15	12	43	44	....	....	....	0.01	- 2.8	1	7,743	n.	42	n.	29	11	9	11	5.5	T.
Ohio Val. and Tenn.							33.6	+ 4.5										80	2.86	- 1.0										8.0	
Chattanooga	762	106	112	29.38	30.21	+ .05	46.1	+ 5.5	74	25	54	6	31	38	36	41	37	76	3.44	- 2.1	10	5,152	s.	36	sw.	29	4	4	23	7.8	0.2
Knoxville	1,004	93	100	29.10	30.18	+ .05	43.8	+ 6.3	72	25	52	10	31	36	33	40	37	81	3.17	- 1.8	10	4,130	ne.	32	sw.	29	1	5	25	8.6	T.
Memphis	399	76	97	29.77	30.21	+ .05	43.6	+ 3.3	73	23	51	11	31	36	36	39	36	78	1.19	- 4.0	7	7,560	s.	64	w.	29	4	2	25	8.1	0.6
Nashville	546	79	91	29.61	30.21	+ .05	42.8	+ 3.8	73	23	51	5	31	34	35	38	36	81	2.34	- 2.5	13	5,325	se.	36	sw.	29	3	6	22	8.1	0.5
Lexington	989	75	102	29.08	30.18	+ .05	37.2	+ 4.2	68	24	45	2	31	30	37	....	....	....	3.35	- 0.5	14	9,205	s.	48	sw.	29	3	6	22	8.1	6.0
Louisville	525	111	132	29.60	30.20	+ .06	37.8	+ 3.5	72	24	45	3	31	30	38	35	31	76	3.25	- 0.6	12	6,889	s.	42	sw.	29	1	7	23	8.4	10.0
Evansville	431	72	82	29.69	30.18	+ .04	35.8	+ 3.5	70	23	43	2	31	29	43	....	....	....	2.84	- 0.8	14	6,715	s.	38	w.	29	2	7	22	8.2	10.5
Indianapolis	822	154	164	29.24	30.16	+ .04	31.3	+ 3.1	67	23	38	4	31	24	28	29	27	83	2.76	0.0	15	8,469	s.	39	sw.	29	4	3	24	8.3	10.7
Cincinnati	628	152	160	29.48	30.18	+ .06	35.7	+ 3.4	69	24	43	7	31	29	27	33	29	77	2.57	- 0.8	15	5,613	se.	36	w.	29	3	6	22	8.0	11.3
Columbus	824	173	224	29.25	30.16	+ .05	32.8	+ 4.2	66	24	40	4	31	26	27	30	27	81	2.52	- 0.4	15	9,892	s.	44	nw.	30	3	10	18	7.6	13.4
Pittsburg	842	336	352	29.22	30.16	+ .05	35.1	+ 4.4	66	24	43	10	13	28	32	32	28	76	3.10	+ 0.2	15	8,344	s.	42	nw.	27	5	8	18	7.5	16.3
Parkersburg	638	77	84	29.50	30.17	+ .05	38.0	+ 6.7	71	24	46	11	31	30	31	34	31	84	3.62	+ 0.4	13	4,815	s.	28	nw.	29	4	6	21	8.0	8.4
Elkins	1,940	41	50	28.06	30.19	+ .07	35.8	+ 8.0	70	22	46	6	31	26	41	32	30	86	2.98	- 0.4	16	3,137	w.	34	w.	27	7	6	18	7.1	4.8
Lower Lake Region.							28.3	+ 4.2										80	2.93	+ 0.3										7.9	
Buffalo	767	178	206	29.26	30.12	+ .05	28.7	+ 4.0	57	24	35	3	31	22	29	27	24	81	3.12	- 0.2	18	13,442	sw.	60	sw.	19	4	6	21	7.6	19.5
Canton	448	10	71	29.63	30.13	......	18.7	+ 2.0	48	5	28	-23	13	9	49	....	....	....	3.00	- 0.2	15	9,378	sw.	46	w.	6	3	8	20	8.0	13.4
Oswego	335	76	91	29.74	30.13	+ .06	26.6	+ 2.7	56	24	34	- 8	19	19	42	25	22	83	3.88	+ 0.7	19	9,954	s.	35	nw.	28	0	5	26	9.0	25.7
Rochester	523	81	102	29.54	30.14	+ .07	28.8	+ 4.8	64	24	35	- 0	12	22	32	26	22	78	2.82	- 0.3	15	7,223	sw.	37	w.	25	0	7	24	8.5	22.5
Syracuse	597	97	113	29.46	30.12	+ .05	27.0	+ 4.0	60	24	35	- 9	19	19	39	....	....	....	3.00	+ 0.9	18	9,924	s.	46	w.	6	1	4	26	8.8	32.5
Erie	713	92	102	29.32	30.12	+ .04	31.8	+ 5.3	65	24	38	6	13	26	26	29	25	76	2.44	- 0.6	16	9,792	s.	36	nw.	27	3	4	24	8.3	17.1
Cleveland	762	190	201	29.28	30.13	+ .04	31.2	+ 5.0	65	24	38	1	13	25	24	29	25	77	2.96	+ 0.5	18	12,877	s.	44	nw.	31	1	9	21	8.0	23.5
Sandusky	629	62	70	29.42	30.13	+ .04	31.3	+ 5.0	66	24	38	3	13	25	26	....	....	....	2.52	+ 0.4	14	7,057	sw.	31	n.	30	6	7	18	7.1	15.3
Toledo	628	207	246	29.44	30.14	+ .05	30.6	+ 5.0	66	23	38	3	13	23	28	28	25	81	3.01	+ 1.1	13	11,695	sw.	43	ne.	16	7	8	16	6.5	15.8
Detroit	730	218	258	29.31	30.13	+ .05	28.6	+ 4.3	61	24	35	4	7	22	29	26	23	81	2.51	+ 0.5	11	11,911	sw.	50	e.	29	5	7	19	7.1	11.4

TABLE I.—*Climatological data for U. S. Weather Bureau stations, January, 1909.*—Continued.

Stations.	Elevation of instruments: Barometer above sea level, feet.	Elevation of instruments: Thermometers above ground.	Elevation of instruments: Anemometer above ground.	Pressure, in inches: Actual, reduced to mean of 24 hours.	Pressure, in inches: Sea level, reduced to mean of 24 hrs.	Pressure, in inches: Departure from normal.	Temperature: Mean max. + mean min. ÷ 2.	Temperature: Departure from normal.	Temperature: Maximum.	Temperature: Date.	Temperature: Mean maximum.	Temperature: Minimum.	Temperature: Date.	Temperature: Mean minimum.	Temperature: Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Precipitation, in inches: Total.	Precipitation: Departure from normal.	Precipitation: Days with .01, or more.	Wind: Total movement, miles.	Wind: Prevailing direction.	Maximum velocity: Miles per hour.	Maximum velocity: Direction.	Maximum velocity: Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness during daylight, tenths.	Total snowfall.
Upper Lake Region.							21.4	+ 3.3										81	1.50	− 0.4										7.1	
Alpena	609	13	92	29.42	30.11	+ .07	22.2	+ 3.5	49	24	29	− 5	7	16	27	21	18	85	1.18	− 1.0	11	9,899	sw.	44	w.	24	3	10	18	7.5	3.8
Escanaba	612	40	82	29.42	30.12	+ .07	18.6	+ 4.1	43	25	26	−17	12	12	33	17	13	78	0.74	− 0.8	12	8,223	sw.	40	n.	30	8	5	18	6.7	4.5
Grand Haven	632	54	92	29.41	30.13	+ .06	26.7	+ 2.2	57	23	33	1	6	21	22	25	23	84	2.44	− 0.4	12	10,586	se.	40	n.	30	5	7	19	7.3	11.3
Grand Rapids	707	121	162	29.33	30.13	+ .07	27.4	+ 3.6	59	24	34	1	6	21	25	25	23	83	2.20	− 0.6	8	9,557	s.	42	w.	24	4	9	18	7.7	9.0
Houghton	668	66	74	29.32	30.09	+ .04	16.4	+ 1.9	47	26	24	−17	7	9	33	....	....	....	1.51	− 0.5	19	6,127	nw.	38	n.	29	4	7	20	7.5	17.7
Marquette	734	77	116	29.27	30.11	+ .07	18.8	+ 2.9	48	26	26	−15	7	12	24	16	12	75	1.07	− 1.0	13	10,174	w.	46	nw.	29	7	9	15	6.4	8.4
Port Huron	638	70	120	29.40	30.12	+ .06	27.1	+ 5.3	62	24	34	2	13	20	29	25	21	80	2.37	+ 0.5	11	10,022	nw.	45	w.	24	8	3	20	7.2	14.5
Sault Sainte Marie	614	40	61	29.39	30.12	+ .09	16.6	+ 3.3	40	4	24	−14	31	9	30	15	11	82	1.61	− 0.6	15	8,015	e.	52	w.	25	5	4	22	8.0	10.3
Chicago	823	140	310	29.23	30.15	+ .05	28.8	+ 4.1	65	23	35	−10	6	22	42	27	24	81	1.96	0.0	8	9,946	sw.	48	nw.	29	4	5	22	7.7	8.6
Milwaukee	681	122	139	29.27	30.15	+ .07	24.4	+ 4.6	54	4	31	−17	6	17	40	23	20	84	2.29	+ 0.3	9	8,955	nw.	37	e.	29	7	10	14	6.1	12.8
Green Bay	617	49	86	29.42	30.12	+ .06	19.3	+ 4.7	41	26	27	−20	6	12	42	17	14	78	0.66	− 1.0	7	8,867	sw.	47	n.	29	6	7	18	7.4	4.8
Duluth	1,133	11	47	28.83	30.12	+ .03	10.0	− 0.4	40	26	19	−34	6	1	40	9	7	86	1.02	0.0	11	12,382	w.	71	nw.	29	7	12	12	5.9	3.7
North Dakota.							4.3	+ 0.2										88	0.42	− 0.2										5.3	
Moorhead	940	8	57	29.10	30.17	+ .03	5.3	+ 2.6	37	18	15	−28	6	−4	41	4	2	89	0.96	+ 0.2	10	7,836	nw.	44	nw.	28	14	5	12	4.9	10.3
Bismarck	1,674	8	57	28.28	30.19	+ .06	6.3	− 0.4	48	20	16	−30	6	−4	42	4	1	83	0.21	− 0.3	5	8,007	nw.	52	nw.	28	10	12	9	5.4	2.1
Devils Lake	1,482	11	44	28.44	30.13	+ .01	1.2	+ 0.9	41	20	10	−37	6	−8	34	0	−1	89	0.26	− 0.3	5	10,427	w.	48	n.	28	11	10	10	5.3	4.5
Williston	1,875	14	56	28.00	30.08	− .03	4.4	− 2.1	46	20	16	−37	6	−7	46	3	1	89	0.31	− 0.3	5	6,963	sw.	41	nw.	16	12	8	11	5.6	3.1
Upper Miss. Valley.							24.9	+ 3.4										83	1.86	+ 0.1										7.3	
Minneapolis	....	102	208	....	....	....	14.5	....	44	26	22	−26	6	6	43	....	....	....	1.37	+ 0.7	8	9,287	se.	53	n.	29	10	7	14	6.0	12.7
St. Paul	837	171	179	29.19	30.14	+ .03	14.4	+ 2.8	43	26	23	−27	6	6	41	13	9	77	1.56	+ 0.7	6	8,628	se.	54	n.	29	8	13	10	5.4	13.2
La Crosse	714	10	49	29.34	30.16	+ .05	18.3	+ 3.1	46	26	26	−22	6	10	38	....	....	....	1.53	+ 0.4	8	4,712	s.	24	s.	18	7	7	17	6.7	12.5
Madison	974	70	78	29.05	30.16	+ .06	20.0	+ 3.5	50	23	28	−22	6	13	39	18	15	81	2.33	+ 0.8	6	8,534	nw.	40	ne.	29	8	5	18	6.9	13.6
Charles City	1,015	10	49	29.03	30.16	+ .02	17.2	+ 5.8	53	23	26	−23	6	9	38	16	15	93	1.99	+ 1.0	10	6,387	s.	36	n.	29	5	5	21	7.7	12.1
Davenport	606	71	79	29.47	30.17	+ .05	24.9	+ 4.1	66	23	33	−15	6	17	37	23	21	87	1.72	+ 0.2	10	5,846	nw.	36	nw.	29	4	7	20	7.8	6.6
Des Moines	861	84	101	29.20	30.15	+ .01	22.8	+ 2.4	59	23	31	−15	6	15	37	21	19	85	1.61	+ 0.4	7	6,884	sw.	44	nw.	29	4	6	21	7.7	11.5
Dubuque	698	100	117	29.40	30.19	+ .07	21.4	+ 3.1	55	23	30	−19	6	13	35	20	18	86	1.98	+ 0.5	11	5,279	s.	31	nw.	29	5	5	21	7.3	10.0
Keokuk	614	64	77	29.47	30.18	+ .04	28.5	+ 4.8	72	23	37	−10	7	20	41	25	22	81	1.26	− 0.4	6	6,030	nw.	37	nw.	29	8	7	16	6.6	4.6
Cairo	356	87	93	29.80	30.20	+ .04	37.4	+ 2.6	72	23	45	5	31	30	44	34	29	74	2.54	− 1.3	12	8,628	s.	56	w.	29	4	2	25	8.2	4.1
La Salle	536	56	64	29.58	30.18	+ .07	26.7	+ 4.4	68	23	34	−11	6	19	36	....	....	....	1.28	− 0.9	10	6,605	nw.	39	nw.	29	2	9	20	7.7	2.9
Peoria	609	11	45	29.48	30.17	+ .05	26.3	+ 3.2	71	23	34	− 9	6	18	40	25	22	84	1.55	− 0.6	9	6,901	s.	38	nw.	29	4	9	18	7.4	2.7
Springfield, Ill.	644	10	92	29.45	30.16	+ .03	29.1	+ 2.8	73	23	37	− 3	6	22	44	27	23	80	2.03	− 0.2	12	7,508	s.	36	nw.	29	4	2	25	8.1	6.4
Hannibal	534	75	109	29.57	30.17	+ .04	29.4	+ 2.7	77	23	38	− 7	12	21	45	....	....	....	1.95	− 0.2	8	7,571	s.	46	nw.	29	6	4	21	7.5	5.3
St. Louis	567	208	217	29.53	30.16	+ .02	32.8	+ 1.8	73	23	40	− 1	31	25	46	30	27	80	3.20	+ 0.9	11	8,680	s.	52	nw.	29	3	5	23	8.2	13.6
Missouri Valley.							23.8	+ 2.7										80	0.95	0.0										6.5	
Columbia, Mo.	784	11	84	29.30	30.16	+ .03	30.6	+ 3.4	77	23	39	−11	12	22	39	....	....	....	2.48	+ 0.2	7	7,205	s.	60	nw	29	8	6	17	6.5	11.6
Kansas City	963	116	181	29.08	30.16	+ .01	29.5	+ 2.3	69	23	38	− 6	6	22	32	27	23	78	1.25	+ 0.1	8	9,849	s.	74	nw.	29	5	10	16	6.9	5.3
Springfield, Mo	1,324	98	104	28.70	30.14	.00	34.0	+ 2.7	73	23	42	− 3	12	26	48	32	30	87	1.71	− 1.0	6	8,961	s.	59	sw.	28	5	6	20	7.4	10.8
Iola	984	11	50	29.09	30.18	+ .04	32.2	+ 4.6	70	23	40	− 6	12	24	33	....	....	....	0.64	− 0.3	8	7,423	s.	44	nw.	29	2	6	23	8.4	3.5
Topeka	....	85	89	....	....	....	28.2	+ 2.6	66	22	37	−10	12	20	32	....	....	....	0.44	− 0.5	7	7,978	s.	58	nw.	29	7	10	14	6.6	5.1
Lincoln	1,189	11	84	28.84	30.17	+ .02	23.3	+ 2.1	63	3	33	−14	6	14	36	20	15	75	0.85	+ 0.2	4	8,856	s.	72	nw.	28	6	8	17	6.8	5.2
Omaha	1,105	115	121	28.93	30.17	+ .02	22.8	+ 2.3	57	23	31	−13	6	15	36	21	16	78	1.00	+ 0.4	5	7,892	s.	65	nw.	28	5	8	18	7.1	5.0
Valentine	2,598	47	54	27.27	30.14	+ .02	19.4	+ 1.2	58	27	31	−23	11	8	46	16	12	80	0.75	+ 0.2	6	7,764	w.	56	nw.	28	12	18	1	4.1	8.4
Sioux City	1,135	96	164	28.89	30.17	+ .02	19.2	+ 3.6	54	3	27	−17	5	11	36	....	....	....	0.60	0.0	5	11,096	nw.	72	nw.	29	8	8	15	6.5	7.0
Pierre	1,572	70	75	28.40	30.17	+ .04	15.8	+ 1.9	51	20	25	−18	6	6	39	13	7	71	0.27	− 0.2	6	7,533	e.	61	nw.	28	9	11	11	5.4	3.9
Huron	1,306	56	67	28.70	30.18	+ .02	12.2	+ 2.7	44	27	22	−25	5	3	40	10	9	89	0.60	+ 0.1	7	9,539	nw.	56	n.	28	13	3	15	5.3	6.5
Yankton	1,233	49	57	28.78	30.16	.00	18.6	+ 3.1	53	27	28	−18	5	10	45	....	....	....	0.77	+ 0.2	8	7,267	nw.	58	nw.	29	7	5	19	6.7	7.9
Northern Slope.							18.3	− 0.7										75	0.82	0.0										5.7	
Havre	2,505	11	44	27.28	30.07	− .03	5.3	− 8.2	50	19	17	−40	6	−6	54	5	2	83	1.30	+ 0.6	9	6,682	sw.	36	sw.	18	10	10	11	5.7	13.0
Miles City	2,371	26	48	27.46	30.16	− .04	11.6	− 2.9	49	3	23	−30	11	0	38	8	4	79	0.65	0.0	9	3,629	s.	30	nw.	28	12	15	4	4.6	7.1
Helena	4,110	8	56	25.66	30.06	− .09	11.8	− 8.2	51	21	21	−30	10	2	37	10	5	72	1.38	+ 0.4	12	3,786	nw.	37	sw.	18	5	15	11	6.2	19.8
Kalispell	2,962	11	34	26.79	29.99	− .13	13.8	− 5.8	48	3	22	−34	11	5	48	12	8	79	1.80	+ 0.2	17	3,838	nw.	25	n.	4	5	9	17	7.1	15.6
Rapid City	3,234	46	50	26.54	30.12	+ .02	21.6	+ 0.1	60	27	34	−18	11	9	52	16	10	72	0.10	− 0.3	2	6,055	se.	36	n.	18	10	5	16	5.8	1.1
Cheyenne	6,088	56	64	23.90	30.02	− .03	30.4	+ 4.8	59	8	42	− 9	11	19	49	24	16	59	0.33	− 0.1	4	8,979	w.	46	w.	31	10	16	5	5.0	4.1
Lander	5,372	26	36	24.51	30.02	− .10	24.4	+ 7.0	55	19	39	−15	29	10	48	20	15	71	0.43	0.0	4	3,374	ne.	28	sw.	7	6	20	5	5.2	4.3
Sheridan	3,790	9	47	25.99	30.07	....	15.9	....	56	18	27	−22	12	4	52	12	9	81	0.30	....	6	3,997	nw.	42	nw.	28	12	13	6	4.4	6.5
Yellowstone Park	6,200	11	48	23.70	29.98	− .16	21.2	+ 3.6	41	17	30	−18	5	12	46	19	16	77	1.61	− 0.6	21	8,987	s.	40	sw.	7	1	6	24	8.4	23.3
North Platte	2,821	11	51	27.10	30.16	+ .04	25.0	+ 3.6	61	18	38	−10	7	12	44	19	14	76	0.29	− 0.2	5	6,077	se.	58	nw.	28	13	11	7	4.8	3.3
Middle Slope.							32.5	+ 3.5										69	0.22	− 0.4										5.5	
Denver	5,291	129	136	24.64	30.00	− .05	36.6	+ 7.5	69	8	50	− 1	10	24	55	28	20	58	0.21	− 0.2	3	5,326	sw.	45	n.	28	8	18	5	4.9	2.1
Leadville	10,248	7	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
Pueblo	4,685	80	86	25.24	30.01	− .04	35.4	+ 6.3	69	9	50	−11	12	20	55	28	17	53	0.24	− 0.1	5	6,067	nw.	48	w.	28	11	15	5	4.5	3.9
Concordia	1,398	42	50	28.64	30.18	+ .04	25.0	+ 0.6	64	28	34	− 7	6	16	37	22	19	81	0.21	− 0.5	3	5,511	s.	45	nw.	28	1	20	10	6.4	1.9
Dodge City	2,509	44	54	27.45	30.15	+ .04	30.0	+ 2.7	74	22	42	− 8	11	18	42	24	19	70	0.29	− 0.2	4	7,267	se.	43	nw.	28	14	14	3	4.2	2.7
Wichita	1,358	90	120	28.70	30.19	+ .06	30.6	+ 0.9	69	22	40	− 5	12	22	35	28	23	78	0.27	− 0.5	6	9,013	s.	62	nw.	29	3	11	17	7.3	3.0
Oklahoma	1,214	10	47	28.82	30.14	+ .03	37.6	+ 2.9	79	22	47	− 2	12	28	57	34	29	75	0.12	− 1.2	5	13,384	s.	66	nw.	29	2	15	14	7.2	0.8
Southern Slope.							47.7	+ 6.2										50	0.04	− 0.9										4.8	
Abilene	1,738	45	54	28.28	30.12	+ .03	48.9	+ 6.3	82	23	61	7	12	37	60	41	34	50	0.06	− 0.8	1	6,741	s.	38	w.	28	5	20	6	6.0	1.0
Amarillo	3,676	10	49	26.28	30.07	+ .01	40.8	+ 6.9	80	8	56	3	12	26	63	32	24	61	0.07	− 0.5	2	10,167	s.	64	w.	28	26	4	1	3.0	0.6
Del Rio	944	8	57	29.10	30.10	+ .04	56.6	+ 6.4	87	28	69	21	12	44	45	....	....	....	0.01	− 1.7	1	5,768	e.	33	nw.	29	9	16	6	5.3	....
Roswell	3,578	9	57	26.40	30.09	+ .05	44.4	+ 5.2	81	9	62	13	13	27	57	35	26	57	0.02	− 0.5	1	4,671	se.	48	nw.	28	11	15	5	4.7	0.2
Southern Plateau.							45.6	+ 4.8										59	1.22	+ 0.2										4.4	
El Paso	3,762	110	133	26.24	30.04	+ .03	50.6	+ 6.5	76	9	64	26	13	37	42	39	24	39	0.04	− 0.5	1	7,622	w.	43	w.	28	13	14	4	3.9	T.
Santa Fe	7,013	33	39	23.24	30.10	+ .06	35.0	+ 6.5	57	9	46	1	11	24	39	27	20	58	0.79	+ 0.2	5	6,352	ne.	39	nw.	28	18	8	5	3.7	5.2
Flagstaff	6,907	8	57	23.33	30.02	− .03	33.0	+ 6.3	56	19	44	6	26	22	39	28	24	76	3.10	+ 1.0	8	5,132	sw.	37	sw.	22	6	10	15	6.5	14.1
Phoenix	1,108	50	56	28.86	30.03	.00	55.6	+ 5.6	77	17	68	35	28	44	35	46	37	56	0.09	− 1.1	2	2,399	e.	17	w.	23	13	11	7	4.5	....
Yuma	141	9	58	29.88	30.03	− .02	57.6	+ 2.9	80	17	71	35	28	44	34	47	37	52	0.05	− 0.4	2	4,261	ne.	29	n.	11	26	4	1	1.7	....
Brawley	†105	11	31	....	....	....	56.9	....	80	17	71	33	30	43	37	49	42	61	0.02	....	1	3,970	nw.	34	sw.	22	14	12	5	4.5	....
Independence	3,910	11	42	25.95	29.97	− .10	41.6	+ 1.1	66	6	52	22	24	31	30	37	31	69	3.27	+ 1.7	10	4.098	s.	38	s.	21	6	15	10	5.8	0.8
Middle Plateau.							34.5	+ 7.1										72	2.10	+ 1.0										6.4	
Reno	4,532	56	63	25.35	29.93	− .20	37.8	+ 5.3	59	16	46	4	11	30	25	33	27	68	4.75	+ 2.8	14	5,253	sw.	52	sw.	30	5	13	13	6.5	6.0
Tonopah	6,089	12	20	23.98	30.06	....	33.8	+ 8.9	56	14	40	11	11	28	19	30	25	69	0.45	− 0.3	4	9,260	se.	40	se.	8	7	19	5	5.2	4.0
Winnemucca	4,344	18	56	25.50	29.93	− .23	36.9	+ 8.1	58	16	47	4	11	27	37	33	28	75	2.98	+ 1.9	13	7,462	sw.	42	sw.	14	3	9	19	7.5	5.5
Modena	5,479	10	43	24.59	30.01	− .09	34.8	+ 7.3	58	18	44	8	11	26	27	31	28	76	0.60	− 0.1	8	8,860	w.	46	sw.	21	6	10	15	6.6	2.5
Salt Lake City	4,366	105	110	25.55	29.97	− .18	38.2	+ 9.4	56	15	46	8	11	31	25	33	26	63	2.70	+ 1.4	15	4,886	se.	40	w.	22	9	7	15	6.2	6.9
Durango	6,546	18	56	23.66	30.13	+ .08	29.7	+ 5.2	51	8	40	− 2	29	19	34	25	21	76	2.59	+ 1.3	11	3,719	nw.	30	w.	28	9	11	11	6.0	17.3
Grand Junction	4,608	43	51	25.41	30.08	+ 0.2	30.2	+ 5.5	53	22	38	7	1	22	26	27	23	79	0.66	0.0	7	3,005	nw.	28	nw.	28	7	6	18	6.8	0.4
Northern Plateau.							29.0	+ 0.3										76	2.72	+ 1.1										7.6	
Baker City	3,471	48	58	26.27	29.91	− .25	30.3	+ 6.4	50	21	38	− 3	10	23	36	27	24	77	1.61	+ 0.3	15	5,424	se.	32	s.	19	4	7	20	7.3	15.1
Boise	2,739	78	86	27.07	29.97	− .22	36.4	+ 7.1	56	17	44	10	12	29	28	33	27	69	4.33	+ 2.4	19	5,216	se.	31	se.	20	4	6	21	7.9	15.9
Lewiston	757	11	[illegible]	29.15	29.99	− .17	26.6	− 7.9	53	3	33	−10	14	20	24	....	....	....	1.91	+ 0.3	14	4,174	e.	47	w.	21	4	6	21	7.5	19.4
Pocatello	4,477	46	54	25.38	29.98	− .22	33.2	+ 8.1	52	17	40	6	29	26	29	30	25	72	3.13	+ 2.5	19	8,153	se.	44	sw.	28	7	5	19	6.9	5.4
Spokane	1,929	101	110	27.84	29.96	− .16	21.6	− 5.1	49	21	28	−16	14	15	35	20	16	80	3.10	+ 0.8	22	4,996	n.	28	sw.	19	2	6	23	8.2	20.2
Walla Walla	1,000	71	79	28.87	29.98	− .17	26.2	− 7.0	62	19	34	−12	9	19	38	24	20	81	2.27	+ 0.8	15	4,858	s.	43	se.	20	5	2	24	7.6	21.1
N. Pac. Coast Reg.							35.2	− 4.3										86	8.66	+ 1.8										8.4	
Blaine	57	4	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
North Head	211	11	56	29.53	29.76	− .29	38.2	− 3.6	52	15	42	20	12	34	19	37	35	89	8.43	+ 0.8	24	15,965	e.	84	se.	15	1	2	28	9.3	10.1
Port Crescent	259	12	29	29.51	29.80	− .19	30.6	− 5.4	55	19	36	7	11	25	21	....	....	....	8.17	+ 2.6	28	6,244	se.	40	ne.	7	0	12	19	8.0	14.2

TABLE I.—*Climatological data for U. S. Weather Bureau stations, January, 1909*—Continued.

Stations.	Elevation of instruments.			Pressure, in inches.			Temperature of the air, in degrees Fahrenheit.												Precipitation, in inches.			Wind.									
	Barometer above sea level, feet.	Thermometers above ground.	Anemometer above ground.	Actual, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hrs.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Total.	Departure from normal.	Days with .01, or more.	Total movement, miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness during daylight, tenths.	Total snowfall.
N. P. Coast Reg—Cont.																															
Seattle	123	185	224	29.71	29.84	—.21	34.2	—5.1	54	19	39	12	13	30	20	33	30	85	6.90	+2.4	25	7,091	se.	42	sw.	19	1	5	25	8.6	14.6
Tacoma	218	113	120	29.59	29.82	—.18	34.0	—4.1	54	19	39	9	13	29	21	33	31	88	8.20	+2.4	23	4,606	sw.	36	ne.	5	0	4	27	9.2	26.2
Tatoosh Island	86	7	57	29.64	29.73	—.25	35.6	—5.6	50	19	39	14	7	32	16	34	30	81	9.26	—2.9	25	22,180	e.	76	e.	5	3	4	24	7.9	14.5
Portland, Oreg.	153	68	106	29.70	29.86	—.22	32.8	—6.3	59	19	38	6	12	28	24	31	29	86	9.29	+2.8	23	5,707	e.	36	s.	20	3	4	24	8.4	15.1
Roseburg	510	9	57	29.27	29.83	—.27	41.3	+0.5	63	29	48	18	10	34	32	39	37	86	10.38	+4.7	22	2,144	s.	26	s.	21	2	10	19	7.6	11.7
Mid. Pac. Coast Reg.							50.4	+3.3										88	11.36	+6.9										8.1	
Eureka	62	62	80	29.81	29.88	—.12	49.2	+2.3	62	15	54	29	10	44	17	47	44	81	14.41	+6.8	25	6,910	se.	48	sw.	8	1	13	17	7.3	
Mount Tamalpais	2,375	11	18	27.47	29.97	—.14	43.1	......	56	17	46	28	11	40	16	42	42	98	15.63	+11.3	26	17,323	se.	66	sw.	20	2	3	26	8.8	0.9
Point Reyes Light	490	7	18	29.40	29.92	......	49.6	......	58	3	53	38	10	46	14	......	......	......	9.78	......	26	19,898	s.	71	s.	25	2	3	26	8.5	
Red Bluff	332	50	56	29.58	29.94	—.18	48.4	+3.0	63	14	52	30	10	44	17	47	46	92	13.42	+9.5	24	6,787	se.	29	s.	21	2	2	27	8.9	
Sacramento	69	106	117	29.92	29.99	—.13	50.6	+5.0	63	16	55	35	11	46	19	49	47	87	9.65	+6.0	25	8,738	se.	48	se.	20	2	10	19	7.7	
San Francisco	155	200	204	29.82	29.99	—.12	51.5	+2.0	60	15	55	38	12	48	18	49	46	84	10.51	+6.2	26	7,504	s.	48	sw.	20	2	6	23	8.6	
San Jose	141	78	88	29.86	30.02	......	52.4	+4.1	69	17	59	82	10	46	23	......	......	......	7.69	+4.8	24	6,722	se.	36	se.	25	0	15	16	7.2	
Southeast Farallon	30	9	17	29.94	29.97	......	51.4	......	58	3	54	41	12	49	10	......	......	......	8.18	+3.9	27	14,767	s.	56	se.	25	4	5	22	8.0	
S. Pac. Coast Reg.							53.4	+2.5										85	8.07	+5.3										7.6	
Fresno	330	67	70	29.69	30.05	—.05	51.8	+6.4	71	16	59	33	10	44	26	49	47	86	4.44	+2.8	17	4,273	se.	30	s.	21	2	0	29	8.7	
Los Angeles	338	159	191	29.71	30.08	.00	54.6	+1.5	76	17	62	41	23	48	25	50	47	82	7.27	+4.4	13	4,579	ne.	31	ne.	24	1	12	18	7.4	
San Diego	87	94	102	29.98	30.08	+.01	54.2	+0.2	70	17	60	42	28	48	21	51	49	87	3.57	+1.6	7	4,247	nw.	31	sw.	22	11	6	14	5.9	
San Luis Obispo	201	47	54	29.85	30.07	—.02	53.0	+2.0	69	17	59	33	29	47	28	50	48	86	17.00	+12.3	21	4,088	s.	24	se.	25	1	6	24	8.3	
West Indies.																															
Grand Turk	11	6	20	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	
San Juan	82	48	90	29.87	29.98	—.04	74.6	......	86	31	80	64	27	69	15	69	67	80	6.16	+3.2	15	6,701	ne.	28	se.	31	15	12	4	3.9	
Panama.																															
Christobal	17	5	60	29.86	29.87	......	77.5	......	83	13	81	70	24	74	10	75	74	88	10.61	......	25	8,767	n.	32	n.	28	6	16	9	6.0	
Bas Obispo	172	4	30	29.70	29.88	......	76.8	......	87	20	84	63	17	70	20	72	72	94	2.59	......	22	3,836	nw.	26	ne.	9	0	30	1	6.0	
Ancon	92	6	69	29.76	29.85	......	79.4	......	90	14	88	68	24	71	22	72	72	89	2.90	......	23	6,118	nw.	24	n.	8	1	25	5	6.0	
Alhajuela	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	2.72	......	22	......	......	......	......	......	......	......	......	......	
Bohio	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	7.29	......	29	......	......	......	......	......	......	......	......	......	
Gatun	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	7.17	......	28	......	......	......	......	......	......	......	......	......	

† Below sea level.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for storms in which the rate of fall equaled or exceeded 0.25 in any 5 minutes, or 0.80 inch in 1 hour, during January, 1909, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive began.	5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex.†	11			0.06														*			
Albany, N. Y	16–17			0.81														*			
Alpena, Mich	22			0.49														*			
Amarillo, Tex.†	2			0.01														0.01			
Anniston, Ala	13			0.64														0.21			
Asheville, N. C	4–5			0.78														0.17			
Atlanta, Ga	16			0.96														0.22			
Atlantic City, N. J	5			1.11														0.30			
Augusta, Ga	5			0.33														0.22			
Baker City, Oreg	7–8			0.34														*			
Baltimore, Md	5			0.54														0.19			
Bentonville, Ark	28			0.21														0.16			
Binghamton, N. Y	17			0.71†														*			
Birmingham, Ala	5			0.56														0.33			
Bismarck, N. Dak	7			0.11														*			
Block Island, R. I	6			1.48														0.54			
Boise, Idaho	21			0.23†														0.15			
Boston, Mass	6			0.71														0.28			
Buffalo, N. Y	23			0.66														*			
Burlington, Vt	17			0.61														*			
Cairo, Ill	5			1.14														0.57			
Canton, N. Y	5–6			0.85														*			
Charles City, Iowa	28–29			1.29														*			
Charleston, S. C	5			0.34														0.21			
Charlotte, N. C	16			0.70														0.17			
Chattanooga, Tenn	16			0.99														0.38			
Cheyenne, Wyo	23			0.18														*			
Chicago, Ill	28–29			0.86†														*			
Cincinnati, Ohio	29			0.42†														0.21			
Cleveland, Ohio	23			0.18														0.15			
Columbia, Mo	28			1.16														0.34			
Columbia, S. C	16			0.44														0.15			
Columbus, Ohio	23			0.28														0.12			
Concord, N. H	5–6			0.96														*			
Concordia, Kans	11			0.08														*			
Corpus Christi, Tex	11			T.														T.			
Davenport, Iowa	28–29			1.04														*			
Del Rio, Tex	27			0.01														0.01			
Denver, Colo	10–11			0.16														*			
Des Moines, Iowa	28–29			0.90														*			
Detroit, Mich	22			0.68														0.15			
Devils Lake, N. Dak	8			0.18														*			
Dodge City, Kans	11			0.16														*			
Dubuque, Iowa	28–29			1.40														*			
Duluth, Minn	22–23			0.53†														*			
Durango, Colo	13			0.58														*			
Eastport, Me	5			1.89														0.44			
Elkins, W. Va	14			0.85														0.15			
El Paso, Tex	28			0.04														0.03			
Erie, Pa	11–12			0.96†														*			
Escanaba, Mich	22–23			0.27														*			
Eureka, Cal	17			1.08														0.54			
Evansville, Ind	25			0.69														0.21			
Flagstaff, Ariz	22–23			1.81														*			

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, etc.*—Continued.

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive began.	Depths of precipitation (in inches) during periods of time indicated. 5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Fort Smith, Ark.	11			0.42														*			
Fort Worth, Tex	12			0.12														*			
Fresno, Cal.	13			0.56														0.16			
Galveston, Tex	11			0.01														T.			
Grand Haven, Mich	23			0.54														0.46			
Grand Junction, Colo	22-23			0.55														*			
Grand Rapids, Mich	22			0.99														0.35			
Green Bay, Wis	22-23			0.24														*			
Greenville, Me.	17			1.40														*			
Hannibal, Mo	28			1.19														0.23			
Harrisburg, Pa.	22			0.10														0.05			
Hartford, Conn.	5-6			1.03														*			
Hatteras, N. C.	5	8:45 a. m.	7:35 p. m.	1.97	12:50 p. m.	1:45 p. m.	0.17	0.16	0.19	0.32	0.41	0.52	0.63	0.67	0.69	0.78	0.91	0.99			
Havre, Mont.	8-9			0.61														*			
Helena, Mont.	8-9			0.46														*			
Houghton, Mich.	29-30			0.37†														*			
Huron, S. Dak	15			0.27														*			
Independence, Cal.	21			1.24														0.27			
Indianapolis, Ind.	22			0.98														*			
Iola, Kans.	25			0.11														0.10			
Jacksonville, Fla.	5			0.98														0.55			
Jupiter, Fla.	1	‡9:30 p. m.	3:40 a. m.	1.32	12:04 a. m.	12:49 a. m.	0.11	0.09	0.13	0.16	0.27	0.34	0.74	0.57	0.63	0.72					
Do.	4	11:50 a. m.	9:00 p. m.	1.98	2:14 p. m.	2:47 p. m.	0.94	0.08	0.12	0.19	0.28	0.36	0.58	0.64							
Kalispell, Mont.	7-8			0.53†														*			
Kansas City, Mo.	28			0.73														0.23			
Keokuk, Iowa	28			0.70														*			
Key West, Fla.	5	10:36 a. m.	12:06 p. m.	0.44	10:45 p. m.	10:57 p. m.	0.03	0.23	0.36	0.38											
Knoxville, Tenn.	16			0.82														0.30			
La Crosse, Wis	28-29			1.13†														*			
Lander, Wyo.	28			0.40														*			
La Salle, Ill.	28			0.80														0.22			
Lewiston, Idaho	7			0.64														*			
Lexington, Ky.	16			0.65														0.18			
Lincoln, Nebr.	28			0.59														*			
Little Rock, Ark.	22			0.19														0.19			
Los Angeles, Cal.	21			2.98														0.50			
Louisville, Ky.	28			0.28														0.25			
Lynchburg, Va.	5			0.45														0.15			
Macon, Ga	5			0.60														0.27			
Madison, Wis.	28-29			1.21														*			
Marquette, Mich.	30			0.30†														*			
Memphis, Tenn	28			0.23														0.21			
Meridian, Miss.	4			0.32														0.27			
Milwaukee, Wis.	23			0.22														*			
Minneapolis, Minn	28-29			0.89														*			
Mobile, Ala.	14			0.58														0.32			
Modena, Utah	22			0.39														0.10			
Montgomery, Ala	15-16	D. N.	8:25 a. m.	1.39	7:03 a. m.	8:00 a. m.	0.34	0.12	0.33	0.47	0.56	0.59	0.62	0.63	0.64	0.66	0.82	1.03			
Moorhead, Minn	23-24			0.58														*			
Mount Tamalpais, Cal.	8			1.23														0.43			
Mount Weather, Va.	16-17			1.38														*			
Nantucket, Mass.	6			1.97														0.43			
Nashville, Tenn.	4			0.24														0.21			
New Haven, Conn.	5			1.28														0.31			
New Orleans, La	14	3:55 p. m.	8:50 p. m.	1.35	6:22 p. m.	7:10 p. m.	0.18	0.09	0.17	0.27	0.41	0.55	0.67	0.73	0.82	0.90	0.95				
Do.	15	3:30 p. m.	5:30 p. m.	0.69	4:06 p. m.	4:25 p. m.	0.08	0.11	0.18	0.31	0.39										
Do.	15	D. N.	D. N.	0.45	9:12 p. m.	9:28 p. m.	0.07	0.06	0.25	0.36											
New York, N. Y	5			1.23														0.38			
Norfolk, Va.	5			0.47														0.10			
Northfield, Vt	17			0.92														*			
North Head, Wash.	31			1.57														0.25			
North Platte, Nebr	5-6			0.19														*			
Oklahoma, Okla.	25			0.04														0.04			
Omaha, Nebr.	28-29			0.63														*			
Oswego, N. Y	12			0.82														*			
Palestine, Tex	28			0.12														0.12			
Parkersburg, W. Va.	5			0.44														0.19			
Pensacola, Fla.	22	2:30 p. m.	4:55 p. m.	0.60	4:27 p. m.	4:34 p. m.	0.28	0.20	0.31												
Peoria, Ill	28-29			0.80														*			
Philadelphia, Pa	4-5			0.95														*			
Phoenix, Ariz	23			0.08														0.06			
Pierre, S. Dak	15			0.08														*			
Pittsburg, Pa.	16-17			0.83														*			
Pocatello, Idaho	21-22			0.75														*			
Point Reyes Light, Cal.	23			0.66														0.43			
Port Huron, Mich.	22			0.76														0.15			
Portland, Me	6			0.79														0.26			
Portland, Oreg	18-19			1.68														*			
Providence, R. I	16-17			0.90														*			
Pueblo, Colo.	10-11			0.21														*			
Raleigh, N. C.	16			0.94														0.21			
Rapid City, S. Dak	6			0.07														*			
Red Bluff, Cal.	14			1.42														0.54			
Reno, Nev	13-14			1.19														*			
Richmond, Va	5			0.47														0.39			
Rochester, N. Y	11-12			0.85														*			
Roseburg, Oreg.	2			0.70														0.35			
Roswell, N. Mex	12			0.02														*			
Sacramento, Cal.	20			1.20														0.40			
St. Louis, Mo.	28			1.35														0.45			
St. Paul, Minn	28-29			1.05														*			
Salt Lake City, Utah	21-22			0.53														*			
San Antonio, Tex	11			0.10														0.08			
San Diego, Cal.	26			0.70														0.33			
Sand Key, Fla.	2			0.59														0.22			
Sandusky, Ohio	11-12			0.55														*			
San Francisco, Cal	14			0.77														0.39			
San Jose, Cal	20			0.76														0.29			
San Luis Obispo, Cal.	25			2.22														0.94			
Santa Fe, N. Mex	27			0.38														0.38			
Sault Sainte Marie, Mich	6			0.47														*			
Savannah, Ga	5			0.46														0.26			
Scranton, Pa	5			0.54†														0.15			
Seattle, Wash.	19			1.24														0.17			

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, etc.*—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Sheridan, Wyo	6–7			0.16														*			
Shreveport, La	4			0.23														0.23			
Sioux City, Iowa	28–29			0.32														*			
Southeast Farallon, Cal	25			1.33														0.36			
Spokane, Wash	19–20			0.56														*			
Springfield, Ill	28			1.15														*			
Springfield, Mo	11			0.95														*			
Syracuse, N. Y	29–30			0.80														*			
Tacoma, Wash	18			0.66														0.16			
Tampa, Fla	4–5	6:37 p. m.	7:10 a. m.	1.67	6:48 p. m.	7:10 p. m.	0.01	0.19	0.52	0.73	0.79	0.83									
Tatoosh Island, Wash	18			0.94														0.43			
Taylor, Tex	9			0.01														0.01			
Thomasville, Ga	29			0.23														0.20			
Toledo, Ohio	22			0.56														0.21			
Tonopah, Nev	21–22			0.36														*			
Topeka, Kans	28			0.14														0.05			
Valentine, Nebr	14–15			0.34														*			
Vicksburg, Miss	28			0.27														0.27			
Walla Walla, Wash	7–8			0.49														*			
Washington, D. C	5			0.57														0.21			
Wichita, Kans	25			0.05														0.05			
Williston, N. Dak	7–8			0.15														*			
Wilmington, N. C	5			0.85														0.25			
Winnemucca, Nev	13–14			0.88†														*			
Wytheville, Va	5			0.66														0.25			
Yankton, S. Dak	28			0.43														*			
Yellowstone Park, Wyo	9			0.29														*			
Yuma, Ariz	22			0.04														*			
Honolulu, T. H																					
San Juan, P. R	6	1:59 p. m.	2:35 p. m.	0.41	2:17 p. m.	2:23 p. m.	0.02	0.30	0.37												
Do	7	4:24 p. m.	8:35 p. m.	1.01	6:35 p. m.	6:55 p. m.	0.14	0.24	0.60	0.68	0.76										
Do	24	9:25 a. m.	3:10 p. m.	2.68	9:53 a. m.	10:48 a. m.	0.04	0.07	0.13	0.23	0.35	0.43	0.49	0.56	0.61	0.77	0.88	0.96			
					12:02 p. m.	12:59 p. m.	1.29	0.09	0.17	0.23	0.31	0.46	0.56	0.74	0.87	0.97	1.04	1.14			

* Self register not working. † Estimated. ‡ December 31, 1908.

TABLE III.—*Data furnished by the Canadian Meteorological Service, January, 1909.*

Stations.	Pressure. Actual, reduced to mean of 24 hours.	Pressure. Sea level, reduced to mean of 24 hours.	Pressure. Departure from normal.	Temperature. Mean.	Temperature. Departure from normal.	Temperature. Mean maximum.	Temperature. Mean minimum.	Precipitation. Total.	Precipitation. Departure from normal.	Precipitation. Total snowfall.
	Ins.	Ins.	Ins.	°	°	°	°	Ins.	Ins.	Ins.
St. Johns, N. F	29.78	29.93	+.07	24.6	+ 0.8	31.7	17.5	4.18	−1.73	9.0
Sydney, C. B. I	30.00	30.04	+.11	23.0	+ 2.5	30.7	15.2	3.65	−1.45	19.5
Halifax, N. S	29.97	30.08	+.11	23.2	+ 1.4	32.5	13.8	5.16	−0.61	21.0
Grand Manan, N. B	30.01	30.06	+.07	26.4	+ 3.0	35.8	16.9	8.16	+3.25	35.5
Yarmouth, N. S	30.00	30.07	+.07	27.2	+ 0.9	35.3	19.1	3.57	−1.84	17.8
Charlottetown, P. E. I	30.01	30.05	+.09	18.4	+ 1.4	26.4	10.4	3.06	−0.90	15.7
Chatham, N. B	30.07	30.10	+.13	11.8	+ 2.0	22.5	1.0	4.85	+1.26	24.8
Father Point, Que	30.08	30.11	+.13	7.5	+ 0.5	17.1	− 2.1	1.58	−1.27	13.6
Quebec, Que	29.77	30.12	+.10	11.0	+ 1.9	19.1	2.9	5.04	+1.03	40.7
Montreal, Que	29.89	30.11	+.07	15.3	+ 3.6	23.3	7.2	4.58	+0.85	21.3
Rockliffe, Ont	29.48	30.12	+.10	9.6	+ 3.2	20.7	− 1.5	1.33	−0.99	7.0
Ottawa, Ont	29.87	30.22	+.19	13.7	+ 4.1	21.3	6.0	3.36	+0.37	13.6
Kingston, Ont	29.82	30.16	+.11	21.6	+ 4.5	29.2	13.9	2.48	−0.97	10.6
Toronto, Ont	29.73	30.13	+.08	26.4	+ 5.0	33.6	19.1	2.66	−0.26	17.8
White River, Ont	......	......	......	......	......	......	......	......	......	......
Port Stanley, Ont	29.47	30.13	+.06	26.0	+ 3.8	32.8	19.1	2.66	−0.33	12.9
Southampton, Ont	29.36	......	......	24.3	+ 3.9	31.9	16.7	7.55	+3.50	33.6
Parry Sound, Ont	29.38	30.12	+.11	19.4	+ 5.6	28.8	10.1	2.66	−1.42	9.5
Port Arthur, Ont	29.37	30.13	+.06	5.4	+ 2.3	16.6	− 5.9	1.20	+0.38	10.9
Winnipeg, Man	......	......	......	−2.5	+ 4.3	7.5	−12.4	0.73	−0.15	6.3
Minnedosa, Man	28.15	30.10	.00	−2.9	+ 4.3	7.4	−13.2	0.45	−0.35	4.3
Qu' Appelle, Assin	27.63	30.03	−.05	−3.4	+ 0.4	6.9	−13.7	0.76	+0.26	7.6
Medicine Hat, Alberta	27.63	30.03	−.04	8.1	+ 2.6	19.1	− 2.8	0.35	−0.22	3.5
Swift Current, Sask	27.33	30.06	−.03	1.6	− 1.5	10.8	− 7.7	0.50	−0.14	5.0
Calgary, Alberta	26.24	29.99	−.04	3.6	− 4.8	14.3	− 7.1	0.58	+0.05	5.8
Banff, Alberta	25.12	29.98	−.02	1.9	−10.2	11.0	− 7.1	3.94	+2.75	39.4
Edmonton, Alberta	27.58	30.04	+.01	−5.0	− 6.8	6.1	−16.2	0.49	−0.19	4.9
Prince Albert, Sask	......	......	......	......	......	......	......	......	......	......
Battleford, Sask	28.21	30.09	+.01	−11.7	− 5.8	3.0	−20.5	0.22	−0.18	2.0
Kamloops, B. C	28.61	29.96	.00	9.5	−15.5	15.7	3.3	0.81	+0.01	0.0
Victoria, B. C	29.70	29.80	−.17	32.5	− 6.0	36.5	28.5	3.25	−2.14	0.0
Barkerville, B. C	......	......	......	......	......	......	......	......	......	......
Hamilton, Bermuda	29.95	30.12	−.01	63.9	+ 1.9	68.4	59.5	5.38	−0.44	0.0
Dawson, Yukon	29.19	......	......	−43.2	......	−37.7	−48.6	0.30	......	3.0

TABLE IV.—*Heights of rivers referred to zeros of gages, January, 1909.*

Stations.	Distance to mouth of river.	Flood stage on gage.	Highest water. Height.	Highest water. Date.	Lowest water. Height.	Lowest water. Date.	Mean stage.	Monthly range.
	Miles.	Feet.	Feet.		Feet.		Feet.	Feet.
Republican River.								
Clay Center, Kans. [20]	42	18	6.2	28, 29	5.9	4	.....	0.3
Smoky Hill-Kansas River.								
Abilene, Kans	254	22	1.8	2	0.5	1	1.1	1.3
Manhattan, Kans. [3]	160	18	3.2	9–14	1.7	6–8	2.8	1.5
Topeka, Kans. [18]	87	21	6.2	9, 10	5.8	2–5	6.0	0.4
Missouri River.								
Bismarck, N. Dak	1,309	14	4.6	1	2.6	24–26	3.3	2.0
Pierre, S. Dak. [30]	1,114	14	.....	.....	.....	.....	.....	.....
Sioux City, Iowa	784	17	8.9	31	5.5	1–3	6.9	3.4
Blair, Nebr. [25]	705	15	8.6	6	5.8	1	.....	2.8
Omaha, Nebr. [24]	669	18	8.0	7	5.6	6	.....	2.4
St. Joseph, Mo. [16]	481	10	4.5	23	− 1.8	4, 9	.....	5.7
Kansas City, Mo	388	21	8.2	25	2.7	13	4.9	5.5
Glasgow, Mo	231	21	8.3	23, 31	3.5	19	5.9	4.8
Boonville, Mo	199	20	9.6	31	5.3	12	7.1	4.3
Hermann, Mo. [5]	103	24	8.2	30	3.0	18, 19	5.0	5.2
Minnesota River.								
Mankato, Minn	127	18	4.2	29	2.5	1–22	2.7	1.7
St. Croix River.								
Stillwater, Minn. [31]	23	11	.....	.....	.....	.....	.....	.....
Illinois River.								
La Salle, Ill. [12]	197	18	15.2	4	12.2	8	13.4	3.0
Peoria, Ill	135	14	9.7	30	8.3	4	9.0	1.4
Conemaugh River.								
Johnstown, Pa	64	7	4.8	24	1.0	1–3, 9–11	1.7	3.8
Allegheny River.								
Warren, Pa	177	14	7.5	6	0.8	18–22	2.8	6.7
Parker, Pa	73	20	9.6	24	1.5	22	4.0	8.1
Freeport, Pa	29	20	15.8	25	4.5	1	7.7	11.3
Springdale, Pa	17	27	20.6	25	9.4	1	13.0	11.2
Youghiogheny River.								
Confluence, Pa. [10]	59	10	4.0	24	0.4	5	.....	3.6
West Newton, Pa	15	23	5.2	24	0.4	1–3	1.8	4.8
Monongahela River.								
Fairmont, W. Va	119	25	19.0	15	14.3	1, 2	15.3	4.7
Greensboro, Pa	81	18	13.4	15, 16	6.8	1	8.2	6.6
Lock No. 4, Pa	40	28	17.2	16	8.0	29	10.3	9.2
Muskingum River.								
Zanesville, Ohio	70	25	14.6	25	7.9	14	9.4	6.7
Little Kanawha River.								
Creston, W. Va	38	20	8.9	17	2.1	14	3.6	6.8
New-Great Kanawha River.								
Hinton, W. Va	153	14	6.4	6	2.9	14, 15	4.1	3.5
Charleston, W. Va	58	30	11.3	17	5.3	14	7.2	6.0
Scioto River.								
Columbus, Ohio	110	17	2.6	24, 25	1.6	1–22, 28–31	1.7	1.0
Licking River.								
Falmouth, Ky	30	25	9.0	18	1.5	6	3.0	7.5
Kentucky River.								
Beattyville, Ky	254	30	17.3	15	0.7	28	3.1	16.6
Frankfort, Ky	65	31	13.2	17	6.3	7	7.8	6.9
Wabash River.								
Terre Haute, Ind	171	16	1.3	29–31	0.0	7–22	0.4	1.3
Mount Carmel, Ill. [10]	75	15	1.6	29	1.4	1–12, 21–25	1.4	0.2
Cumberland River.								
Burnside, Ky	518	50	28.7	16	3.0	13	7.8	25.7
Celina, Tenn	383	45	28.9	18	5.1	2	10.4	23.8
Carthage, Tenn	308	40	26.7	19	4.2	1	9.6	22.5
Nashville, Tenn	193	40	29.2	20	10.2	4, 5	15.1	19.0
Clarksville, Tenn	126	43	29.7	21	7.6	5	14.0	22.1
Clinch River.								
Speers Ferry, Va	156	20	7.8	17	1.1	31	2.3	6.7
Clinton, Tenn	52	25	20.5	18	5.5	14	8.9	15.0
South Fork Holston River.								
Bluff City, Tenn. [1]	35	12	4.2	17	1.7	14, 15	2.4	2.5
Holston River.								
Rogersville, Tenn	103	14	5.8	18	2.8	14	3.6	3.0
French Broad River.								
Asheville, N. C	144	4	2.3	6	0.2	28–30	0.7	2.1
Dandridge, Tenn	46	12	4.8	17	1.2	4	2.5	3.6
Tennessee River.								
Knoxville, Tenn	635	12	7.3	18	2.2	15	3.4	5.1
Loudon, Tenn	590	25	9.4	18	1.9	27–29	4.6	7.5
Kingston, Tenn	556	25	11.8	18	3.9	14	5.7	7.9
Chattanooga, Tenn	452	33	16.4	19	5.6	29	8.6	10.8
Bridgeport, Ala	402	24	13.0	20	3.8	30	6.7	9.2
Guntersville, Ala	349	31	20.1	20	7.0	30	11.5	13.1
Florence, Ala	255	16	11.7	21	4.0	30, 31	6.9	7.7
Riverton, Ala	225	32	25.2	21	13.1	30, 31	17.7	12.1
Johnsonville, Tenn	95	21	17.2	22, 23	6.9	31	11.0	10.3
Ohio River.								
Pittsburg, Pa	966	22	13.2	25	2.1	15	6.0	11.1
Coraopolis, Pa	956	25	13.2	25	4.0	15	7.7	9.2
Beaver Dam, Pa	937	27	20.9	25	4.3	1	10.2	16.6
Wheeling, W. Va	875	36	20.7	26	3.3	1	9.6	17.4
Parkersburg, W. Va	785	36	20.4	27	3.7	2	10.2	16.7
Point Pleasant, W. Va	703	39	21.5	27	5.5	5	12.0	16.0
Huntington, W. Va	660	50	25.0	28	8.8	1	16.0	16.2
Catlettsburg, Ky	651	50	25.4	28	8.0	1	15.8	17.4
Portsmouth, Ohio	612	50	25.0	28	8.2	1	15.9	16.8
Maysville, Ky	559	50	24.8	29	8.2	7	15.8	16.6
Cincinnati, Ohio	499	50	26.4	30	9.9	2	17.4	16.5
Madison, Ind	413	46	22.5	21	9.2	3, 4	14.7	13.3
Louisville, Ky	367	28	10.4	21	4.9	3, 4	7.4	5.5
Evansville, Ind	184	35	19.9	23	7.1	1	11.9	12.8
Mount Vernon, Ind	148	35	18.5	22, 23	6.4	1	11.3	12.1
Paducah, Ky	47	40	20.4	24	8.3	2, 3	12.3	12.1
Cairo, Ill	1	45	23.0	25	10.2	16	15.2	12.8
Neosho River.								
Iola, Kans	262	10	− 0.5	23, 24	− 2.3	11	−1.5	1.8
Oswego, Kans	184	20	0.7	1	0.4	29–31	0.6	0.3
Fort Gibson, Okla	3	22	11.4	31	9.7	12–14	10.2	1.7
Canadian River.								
Calvin, Okla. [5]	99	15	4.0	25	3.0	10, 11, 30	3.4	1.0
Black River.								
Blackrock, Ark	67	12	7.0	23	2.0	8–14	3.3	5.0
White River.								
Calicorock, Ark	272	18	2.8	23, 24	0.0	1–12, 14–16	1.0	2.8
Batesville, Ark	217	18	5.3	23	1.8	7, 8	2.9	3.5
Clarendon, Ark	75	30	17.8	29	9.2	12–15	11.2	8.6
Arkansas River.								
Wichita, Kans	832	10	− 0.1	26, 27	− 1.4	11–14	−0.9	1.3
Tulsa, Okla. [2]	551	16	4.5	17	2.5	21–24	3.0	2.0
Webbers Falls, Okla	465	23	7.4	1	6.5	16–18, 31	6.9	0.9
Fort Smith, Ark	403	22	7.0	29	4.9	15	6.3	2.1
Dardanelle, Ark	256	21	6.7	24	4.6	15, 16	5.6	2.1
Little Rock, Ark	176	23	7.3	24	3.6	18	5.1	3.7
Yazoo River.								
Greenwood, Miss	175	38	5.1	1, 24	3.2	31	4.1	1.9
Yazoo City, Miss	80	25	3.6	1	1.4	13, 14	2.3	2.2
Ouachita River.								
Camden, Ark	304	39	16.3	26	5.5	14	7.5	10.8
Monroe, La	122	40	13.5	4	5.9	25, 26	9.1	7.6
Red River								
Arthur City, Tex	688	27	7.6	1	6.7	11–13	7.0	0.9
Fulton, Ark	515	28	11.5	25	8.7	20, 21	9.6	2.8
Shreveport, La	327	29	2.1	28	0.0	24	1.0	2.1
Alexandria, La	118	36	6.6	1	3.5	27	5.0	3.1
Mississippi River.								
Fort Ripley, Minn. [31]	2,082	10	.....	.....	.....	.....	.....	.....
St. Paul, Minn. [31]	1,954	14	.....	.....	.....	.....	.....	.....
Red Wing, Minn. [31]	1,914	14	.....	.....	.....	.....	.....	.....
Reeds Landing, Minn. [12]	1,884	12	0.2	23–28, 30, 31	0.1	13–22, 29	0.1	0.1
La Crosse, Wis. [31]	1,819	12	.....	.....	.....	.....	.....	.....
Prairie du Chien, Wis. [31]	1,759	18	.....	.....	.....	.....	.....	.....

TABLE IV.—*Heights of rivers referred to zeros of gages*—Continued.

Stations.	Distance to mouth of river.	Flood stage on gage.	Highest water.		Lowest water.		Mean stage.	Monthly range.
			Height.	Date.	Height.	Date.		
Mississippi River.—Cont'd.	*Miles.*	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
Dubuque, Iowa (25)	1,699	18	3.6	4	2.8	1	.....	0.8
Leclaire, Iowa (31)	1,609	10	.....	.....	.....	.....	.....	.....
Davenport, Iowa (12)	1,593	15	7.0	31	1.7	5	3.4	5.3
Muscatine, Iowa	1,562	16	10.0	31	2.6	2,6	5.2	7.4
Galland, Iowa † (12)	1,472	8	2.5	29	0.6	3,8,9	1.6	1.9
Keokuk, Iowa (12)	1,463	15	4.7	29	−2.1	8	1.9	6.8
Warsaw, Ill (3)	1,458	18	8.4	23	3.5	6–8	5.6	4.9
Hannibal, Mo (15)	1,402	13	4.2	29	−0.3	10	2.3	4.5
Grafton, Ill	1,306	23	6.6	31	0.3	13	3.7	6.3
St. Louis, Mo	1,264	30	8.0	31	−1.6	12	3.1	9.6
Chester, Ill (1)	1,189	30	6.9	31	−0.5	15	2.9	7.4
Cape Girardeau, Mo	1,128	28	10.2	31	0.6	15	5.2	9.6
New Madrid, Mo	1,003	34	18.9	25	8.0	16	12.2	10.9
Memphis, Tenn	843	33	16.0	27	6.7	18	9.9	9.3
Helena, Ark	767	42	19.0	28,29	7.6	19	11.1	11.4
Arkansas City, Ark	635	42	21.9	30	9.4	21	13.0	12.5
Greenville, Miss	595	42	17.6	30	6.9	21	9.7	10.7
Vicksburg, Miss	474	45	18.5	31	6.9	1,2	9.2	11.6
Natchez, Miss	373	46	18.1	31	9.5	23	11.2	8.6
Baton Rouge, La	240	35	10.1	31	5.9	25	6.9	4.2
Donaldsonville, La	188	28	6.5	31	4.1	2,3	4.6	2.4
New Orleans, La	108	18	4.7	12,13	3.6	2	4.2	1.1
Atchafalaya River.								
Simmesport, La	127	41	12.1	31	7.2	25,26	8.6	4.9
Melville, La	103	37	14.7	31	10.3	26,27	11.9	4.4
Morgan City, La	19	8	4.8	23,24	2.6	31	4.0	2.2
Hudson River.								
Troy, N. Y	154	14	11.5	26	1.5	1	4.9	10.0
Albany, N. Y	147	12	10.0	26	0.2	1	4.0	9.8
Delaware River.								
Hancock (E. Branch), N. Y	287	12	13.3	6	3.6	20	4.8	9.7
Hancock (W. Branch), N. Y	287	10	9.5	6	3.2	15	4.8	6.3
Port Jervis, N. Y	215	14	10.0	7	2.4	4	4.4	7.6
Phillipsburg, N. J. (5)	146	26	14.1	7	0.9	1	4.1	13.2
Trenton, N. J	92	18	8.3	7	1.0	3–5	3.4	7.3
North Branch Susquehanna.								
Binghamton, N. Y	183	14	10.8	25	2.2	1,3	4.1	8.6
Wilkes-Barre, Pa	60	17	16.0	26	2.3	1,2	6.8	13.7
West Branch Susquehanna.								
Williamsport, Pa	39	20	10.8	26	1.3	2–4	3.4	9.5
Susquehanna River.								
Harrisburg, Pa	69	17	9.4	27	0.8	1,2	3.2	8.6
Shenandoah River.								
Riverton, Va	58	22	3.4	26	−0.7	1	0.7	4.1
Potomac River.								
Cumberland, Md	290	8	4.8	25	2.5	2–15	3.3	2.3
Harpers Ferry, W. Va	172	18	8.0	26	0.8	4,15,16	2.3	7.2
James River.								
Lynchburg, Va	260	20	5.7	6	2.3	13,14	3.6	3.4
Columbia, Va	167	18	14.2	6	6.5	13–16	8.7	7.7
Richmond, Va	111	10	7.0	6	1.0	17	2.4	6.0
Dan River.								
Danville, Va	55	8	2.1	6	0.4	13,28,29	0.8	1.7
Roanoke River.								
Clarksville, Va	196	12	4.5	7,19	1.2	14,15	2.3	3.3
Weldon, N. C	129	30	22.7	20	12.1	16	15.3	10.6
Tar River.								
Greenville, N. C	21	22	10.2	1	6.2	15,28	7.6	4.0
Haw River.								
Moncure, N. C	171	25	11.5	17	8.0	11,13–15	8.6	3.5
Cape Fear River.								
Fayetteville, N. C	112	38	17.7	19	5.3	12	8.3	12.4
Pedee River.								
Cheraw, S. C	149	27	14.6	18	4.1	29	6.4	10.5
Smiths Mills, S. C	51	16	14.7	2	8.1	19	11.0	6.6
Lynch Creek.								
Effingham, S. C	35	12	6.5	25,26	4.0	14	5.1	2.5
Black River.								
Kingstree, S. C	45	12	4.0	5–7	2.7	26	3.2	1.3
Catawba-Wateree River.								
Mount Holly, N. C	143	15	3.3	17	2.0	1–6, 8–13, 21–31	2.2	1.3
Catawba, S. C	107	11	6.8	7	2.6	30	4.0	4.2
Camden, S. C	37	24	16.8	18	7.0	30	9.9	9.8
Congaree River.								
Columbia, S. C	52	15	6.8	18	2.3	5,26,31	3.1	4.5
Santee River.								
Ferguson, S. C	82	12	13.5	1	11.0	18,19,31	12.3	2.5
Savannah River.								
Calhoun Falls, S. C	347	15	5.0	7,17	2.9	28,29,31	3.7	2.1
Augusta, Ga	268	32	21.0	18	9.4	31	11.4	11.6
Oconee River.								
Dublin, Ga	79	30	6.0	20	1.1	31	3.1	4.9
Ocmulgee River.								
Macon, Ga	134	18	7.3	6	3.0	31	4.5	4.3
Abbeville, Ga	51	11	10.5	1	3.8	31	5.9	6.7
Flint River.								
Montezuma, Ga	152	20	6.0	2	3.7	30,31	4.9	2.3
Albany, Ga	99	20	6.9	1	1.7	31	2.7	5.2
Bainbridge, Ga	22	22	9.3	1	5.2	31	6.3	4.1
Chattahoochee River.								
Oakdale, Ga	305	18	15.0	6	6.0	12, 13, 26, 27, 29–31	7.4	9.0
West Point, Ga	174	20	7.9	7	3.1	31	4.0	4.8
Eufaula, Ala	90	40	11.0	8,9	3.4	2	6.2	7.6
Alaga, Ala	30	25	10.8	9	4.0	31	5.9	6.8
Coosa River.								
Rome, Ga	266	30	13.2	17,18	1.8	30,31	4.8	11.4
Gadsden, Ala	162	22	14.1	19	3.0	31	6.6	11.1
Lock No. 4, Ala	113	17	10.8	19	2.5	31	5.4	8.3
Wetumpka, Ala	12	45	15.6	20	5.0	4	8.8	10.6
Alabama River.								
Montgomery, Ala	323	35	12.0	21	3.0	4,5	6.0	9.0
Selma, Ala	246	35	13.7	22	3.1	6	7.1	10.6
Black Warrior River.								
Tuscaloosa, Ala	90	43	25.3	18	8.1	3,4	14.4	17.2
Tombigbee River.								
Columbus, Miss	316	33	4.9	18,19	−0.3	31	1.4	5.2
Demopolis, Ala	168	35	19.3	21	5.3	31	7.8	14.0
Pascagoula River.								
Merrill, Miss	78	20	4.4	18,19	1.3	5–7	2.0	3.1
Pearl River.								
Columbia, Miss	110	18	5.5	8	3.8	31	4.6	1.7
Sabine River.								
Logansport, La	315	25	8.0	5	3.7	31	5.2	4.3
Neches River.								
Beaumont, Tex	18	10	1.5	30	0.5	29	1.0	1.0
Trinity River.								
Dallas, Tex	320	25	5.5	21	4.9	29,30	5.2	0.6
Long Lake, Tex	211	40	6.1	3	1.7	29–31	3.4	4.4
Liberty, Tex	20	25	6.7	9	4.7	31	5.6	2.0
Brazos River.								
Waco, Tex	285	24	1.6	1,4,9–12	1.3	29–31	1.5	0.3
Booth, Tex	61	39	4.4	1–4	3.2	27–31	3.8	1.2
Colorado River.								
Austin, Tex	214	18	1.6	1–5	1.2	24–26	1.4	0.4
Columbus, Tex	98	24	9.8	1	5.9	28–31	6.3	3.9
Red River of the North.								
Moorhead, Minn (31)	284	26	.....	.....	.....	.....	.....	.....
Snake River.								
Lewiston, Idaho	144	24	10.4	22	1.5	1	4.5	8.9
Riparia, Wash	67	30	8.8	22	2.1	1	4.5	6.7
Columbia River.								
Wenatchee, Wash	473	40	12.4	22–24	5.1	9	8.7	7.3
Umatilla, Oreg (11)	270	25	7.9	24	1.0	5,6	4.2	6.9
The Dalles, Oreg*	166	40	19.6	21	0.0	10,11	4.0	19.6
Willamette River.								
Albany, Oreg	118	20	23.8	23	5.0	3	12.1	18.8
Portland, Oreg	12	15	20.5	22	2.1	14,15	8.9	18.4
Sacramento River.								
Red Bluff, Cal	265	23	27.9	16	1.8	1	16.4	26.1
Colusa, Cal	156	28	28.0	17	3.7	1	22.6	24.3
Knights Landing, Cal	99	18	19.1	18	2.5	1,2	15.4	16.6
Sacramento, Cal	64	25	29.6	17	7.2	1,2	21.6	22.4
San Joaquin River.								
Pollasky, Cal	203	10	8.5	14	0.0	1–7	1.9	8.5
Firebaugh, Cal	148	14	10.2	24	−0.5	1–5	4.2	10.7
Lathrop, Cal	49	14	18.7	23,24	0.8	1,2	10.8	17.9

*2 days missing. † No observations on 30th and 31st. Figures in parenthesis represent number of days river was frozen during the month.

6——6

Honolulu, T. H., latitude 21° 19′ north, longitude 157° 52′ west; barometer above sea, 38 feet; gravity correction, —0.057 inch, applied. January, 1909.

Day.	Pressure, in inches.* 8 a. m.	Pressure, in inches.* 8 p. m.	Air temperature, degrees Fahrenheit. 8 a. m.	Air temperature 8 p. m.	Maximum.	Minimum.	Moisture. 8 a. m. Wet.	8 a. m. Relative humidity.	8 p. m. Wet.	8 p. m. Relative humidity.	Wind, in miles per hour. 8 a. m. Direction.	8 a. m. Velocity.	8 p. m. Direction.	8 p. m. Velocity.	Precipitation, inches. 8 a. m.	8 p. m.	Clouds. 8 a. m. Amount.	8 a. m. Kind.	8 a. m. Direction, from.	8 p. m. Amount.	8 p. m. Kind.	8 p. m. Direction, from.
							°	%	°	%												
1	30.00	30.00	69.7	69.0	75	67	61.0	60	63.0	72	ne.	10	ne.	15	0.00	0.00	6 4	A.-s. A.-cu.	w. sw.	8 1	A.-cu. Cu.	nw. ne.
2	30.02	29.98	68.2	67.0	73	63	62.0	70	61.0	71	ne.	4	ne.	4	T.	0.00	8	S.-cu.	ne.	2 1	Cu. S.-cu.	ne. ne.
3	29.99	29.99	69.6	67.0	72	62	61.0	60	60.0	66	ne.	4	n.	4	0.00	0.00	4	Cu.	ne.	9	Cu.	ne.
4	30.01	30.02	66.2	69.0	74	64	59.4	68	60.0	59	ne.	5	ne.	5	0.00	0.00	5	Cu.	ne.	8	Cu.	ne.
5	30.02	30.01	65.4	67.5	74	62	58.2	65	60.0	64	ne.	4	ne.	5	0.00	0.00	9	S.-cu.	e.	6	Cu.	e.
6	29.99	29.99	66.0	66.0	72	61	57.0	57	60.0	71	ne.	5	ne.	8	0.00	0.00	Few	A.-s.	0(?)	Few	S.-cu.	ne.
7	30.01	29.98	69.0	69.0	75	61	59.1	55	62.0	67	e.	4	e.	4	0.00	0.00	9	A.-cu.	s.	Few	Cu.	se.
8	29.97	29.93	71.0	71.0	77	67	64.4	70	65.0	72	ne.	7	e.	5	0.00	0.00	6	A.-cu.	se.	8	A.-s.	nw.
9	29.87	29.86	73.2	73.5	76	71	68.5	79	70.0	84	se.	18	s.	4	0.01	T.	4	Cu.	se.	8	S.	e.
10	29.81	29.86	73.5	73.0	75	72	70.2	83	71.0	91	se.	20	s.	14	0.01	0.05	10	S.	s.	10	S.	s.
11	29.85	29.91	74.0	72.0	74	72	70.0	80	71.0	95	s.	19	s.	10	T.	0.30	10	S.	s.	10	N.	s.
12	29.96	29.96	71.0	72.0	75	70	70.6	98	70.0	91	s.	14	s.	7	1.43	0.01	10	N.	s.	6	Cu.	se.
13	29.99	29.97	70.0	70.0	78	67	67.0	86	66.0	81	ne.	3	ne.	3	0.03	0.00	3	A.-cu.	sw.	0	0	0
14	30.00	29.97	70.1	68.0	74	65	66.0	81	65.5	88	ne.	2	ne.	4	0.00	0.00	Few	Cu.	0	Few	A.-s.	0
15	29.98	30.00	66.0	71.5	75	64	63.2	86	67.0	79	w.	6	sw.	1	0.00	0.00	10	A.-s.	s.	Few	S.	e.
16	30.04	30.01	73.0	71.0	75	67	68.0	78	68.0	86	ne.	2	se.	4	0.00	0.00	7 3	A.-s. Cu.-n.	w. se.	1	S.	e.
17	30.04	30.05	71.5	73.0	76	69	67.0	79	69.0	82	se.	4	s.	8	0.00	0.00	8	Cu.	ne.	4	Cu.	se.
18	30.13	30.07	73.3	69.0	77	67	68.0	76	66.0	85	n.	3	e.	3	0.00	0.00	1	S.-cu.	0	0	0	0
19	30.12	30.13	71.0	70.0	75	64	64.1	68	65.0	77	ne.	2	ne.	5	0.00	0.00	1	A.-cu.	0	1	A.-s.	0(?)
20	30.16	30.12	74.0	72.0	77	70	66.0	65	67.0	77	ne.	6	ne.	5	0.00	T.	3 5	A.-cu. S.-cu.	e. e.	6	N.	e.
21	30.18	30.12	71.1	72.0	76	69	65.2	73	65.0	69	e.	12	e.	7	T.	0.00	9	S.-cu.	e.	0	0	0
22	30.19	30.16	73.4	73.0	77	70	65.0	64	68.0	78	ne.	20	e.	20	0.00	0.00	3 4	A.-cu. S.-cu.	e. e.	1	S.	e.
23	30.21	30.19	72.0	70.0	76	66	65.3	70	65.0	77	e.	13	ne.	12	0.01	0.00	4	Cu.	ne.	5	S.	se.
24	30.19	30.14	70.0	71.0	74	65	64.0	72	64.0	68	e.	8	e.	18	0.03	T.	2 6	S.-cu. N.	e. e.	7	S.	e.
25	30.19	30.14	71.0	70.0	74	69	62.0	60	62.0	64	e.	22	n.	4	0.00	0.00	3 1	Ci.-s. Cu.	w. e.	2	Cu.	ne.
26	30.15	30.11	71.6	71.0	75	67	62.4	60	62.0	60	e.	18	e.	14	T.	0.00	5	Cu.	e.	1 4	A.-s. Cu.	sw. ne.
27	30.11	30.06	71.4	71.0	74	68	63.0	63	65.0	72	e.	15	e.	15	T.	T.	4	Cu.	e.	10	Cu.	ne.
28	30.08	30.05	71.0	68.0	75	65	64.0	68	64.0	80	e.	7	ne.	12	0.13	T.	7	S.-cu.	e.	9	N.	e.
29	30.08	30.05	70.0	70.0	74	64	62.3	65	62.0	64	e.	5	e.	4	0.12	0.00	7	Cu.	e.	8	Cu.	ne.
30	30.10	30.04	67.0	68.0	72	64	63.1	81	64.0	80	e.	6	e.	9	0.08	0.09	3 3	Cu. N.	e. e.	8	Cu.	ne.
31	30.08	30.05	68.5	69.0	74	66	60.6	63	64.0	76	ne.	14	e.	10	0.03	0.00	10	A.-s.	sw.	7	A.-s.	w.
Mean....	30.049	30.030	70.4	70.1	74.8	66.4	64.1	71.1	64.9	75.7	ne.	9.1	e.	7.8	1.88	0.45	6.4	Cu.	e.	4.9	Cu.	ne.

Observations are made at 8 a.m. and 8 p. m., local standard time, which is that of 157° 30′ west, and is 5h and 30m slower than 75th meridian time. *Pressure values are reduced to sea level and standard gravity.

RAINFALL IN JAMAICA.

Thru the kindness of Mr. Maxwell Hall, meteorologist to the government of Jamaica and now in charge of the meteorological service of that island, we have received the following data:

Comparative table of rainfall.

[Based upon the average stations only.]

JANUARY, 1909.

Divisions.	Relative area.	Number of stations.	Rainfall. 1908.	Rainfall. Average.
Northeastern division	25	17	8.78	5.90
Northern division	22	41	4.08	3.34
West-central division	26	20	2.05	2.36
Southern division	27	26	2.50	1.63
Means	100	....	4.35	3.31

The rainfall over the island for January was therefore 1 inch above the average.

The greatest rainfall recorded was 27.37 inches, at Greenvale, Portland, and no rain fell at Glasgow Estate and White Hall.

At Georgetown, Grand Cayman, 4.03 inches fell on 10 days. The greatest fall was 2.46 inches on the 8th.

Chart I. Hydrographs for Seven Principal Rivers of the United States, January, 1909.

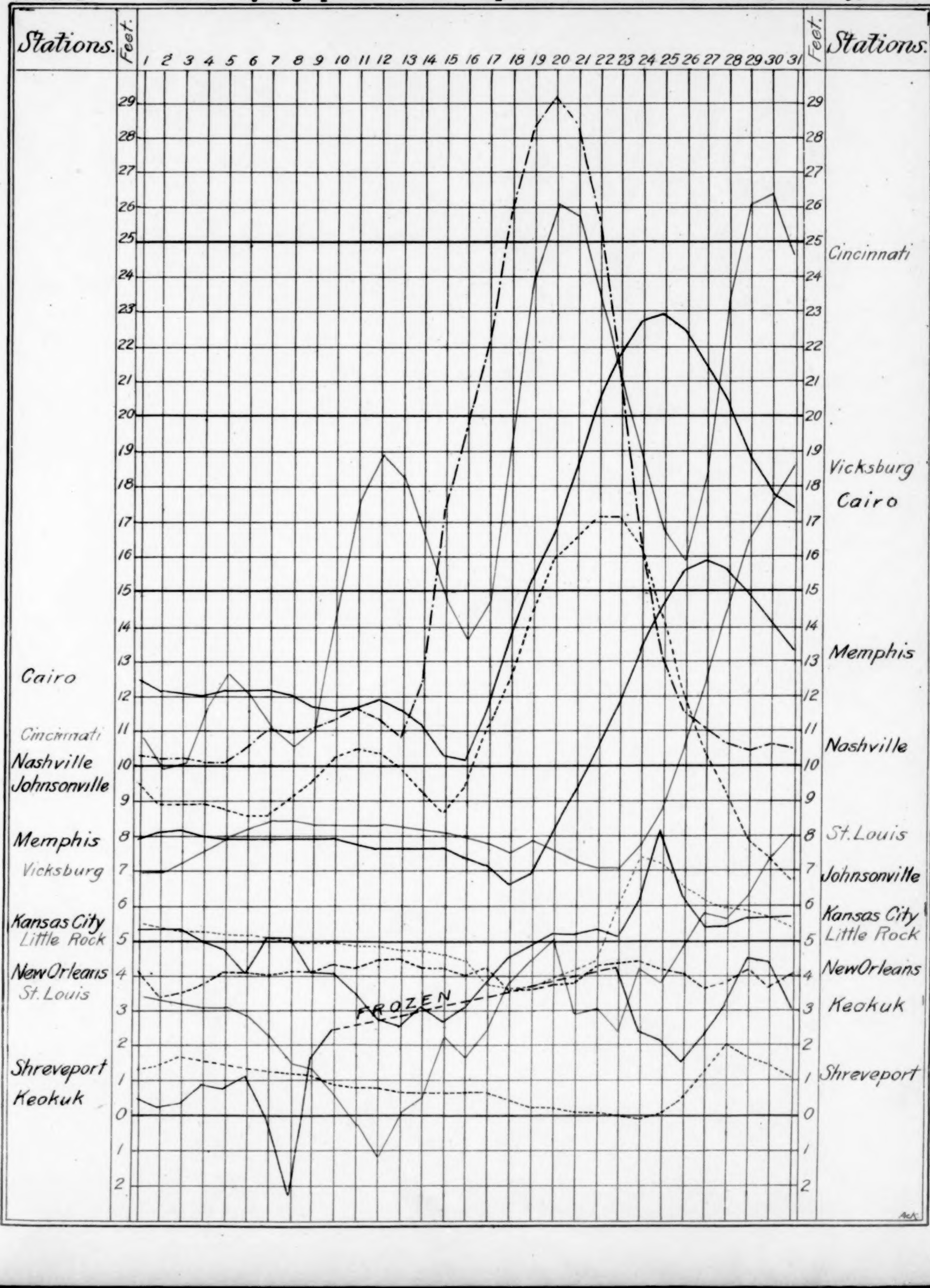


Chart II. Tracks of Centers of High Areas, January, 1909.

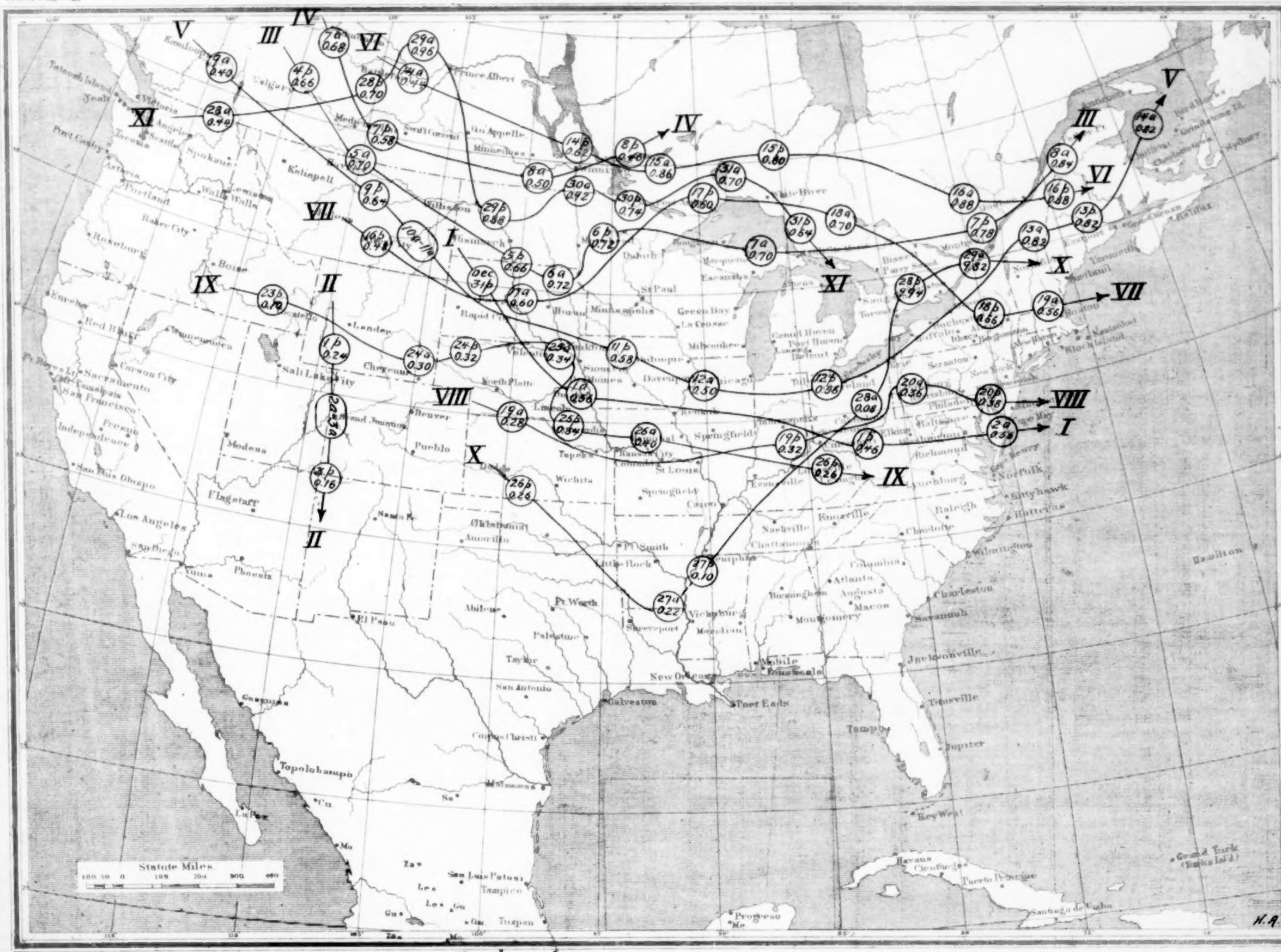


Chart III. Tracks of Centers of Low Areas, January, 1909.

Chart III. Tracks of Centers of Low Areas, January, 1909.

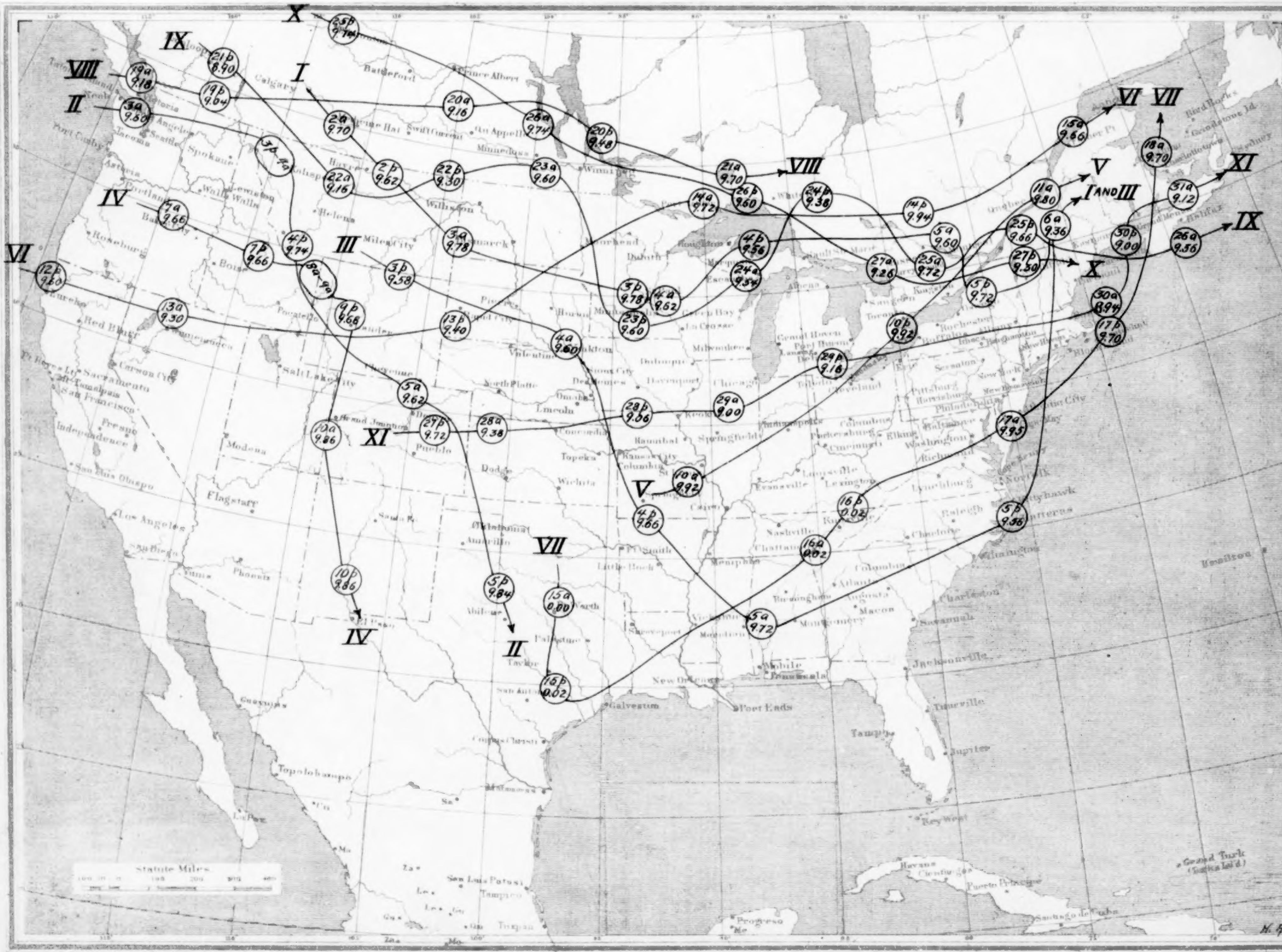


Chart IV. Total Precipitation, January, 1909.

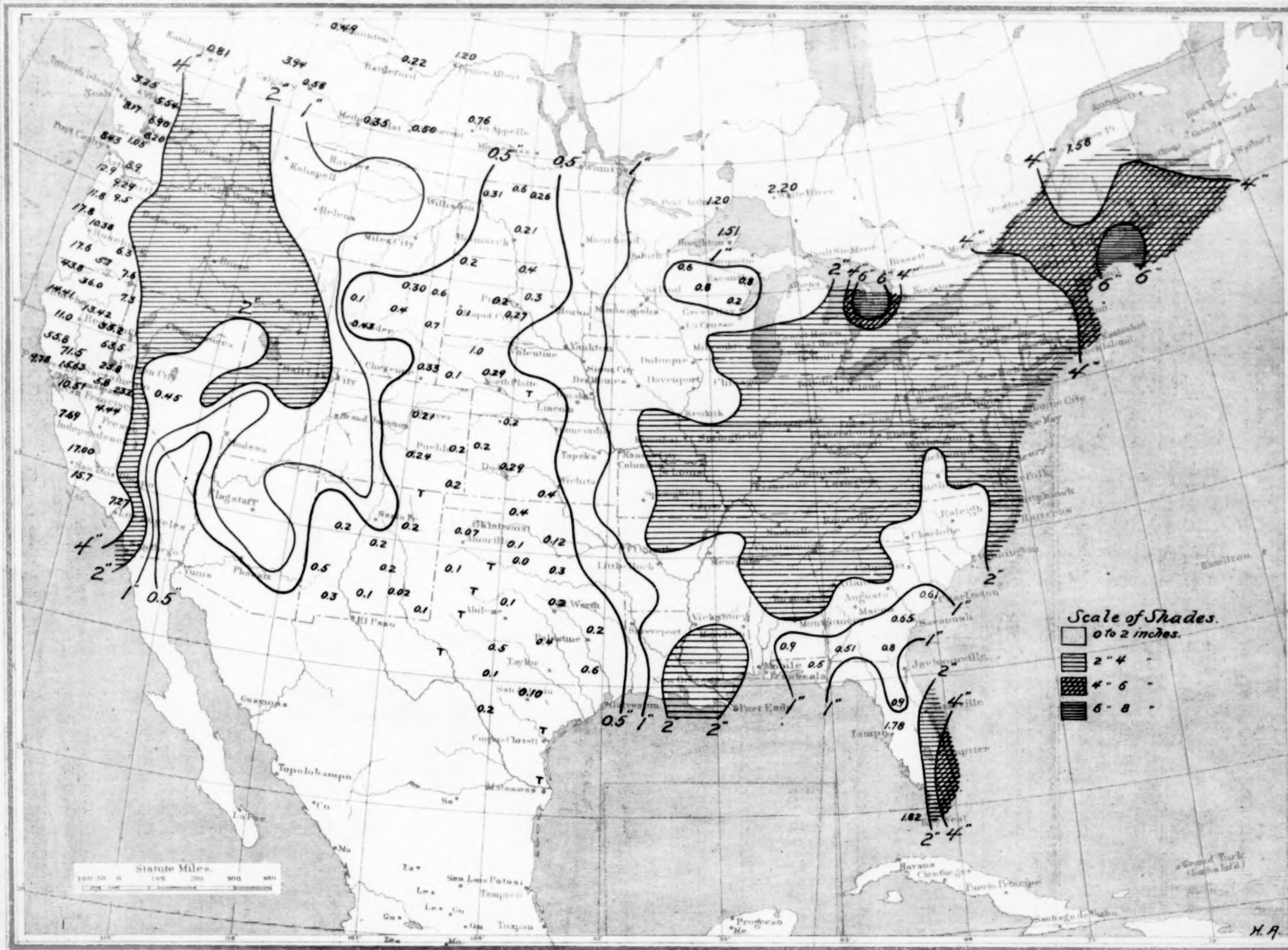


Chart V. Percentage of Clear Sky between Sunrise and Sunset, January, 1909.

Chart V. Percentage of Clear Sky between Sunrise and Sunset, January, 1909.

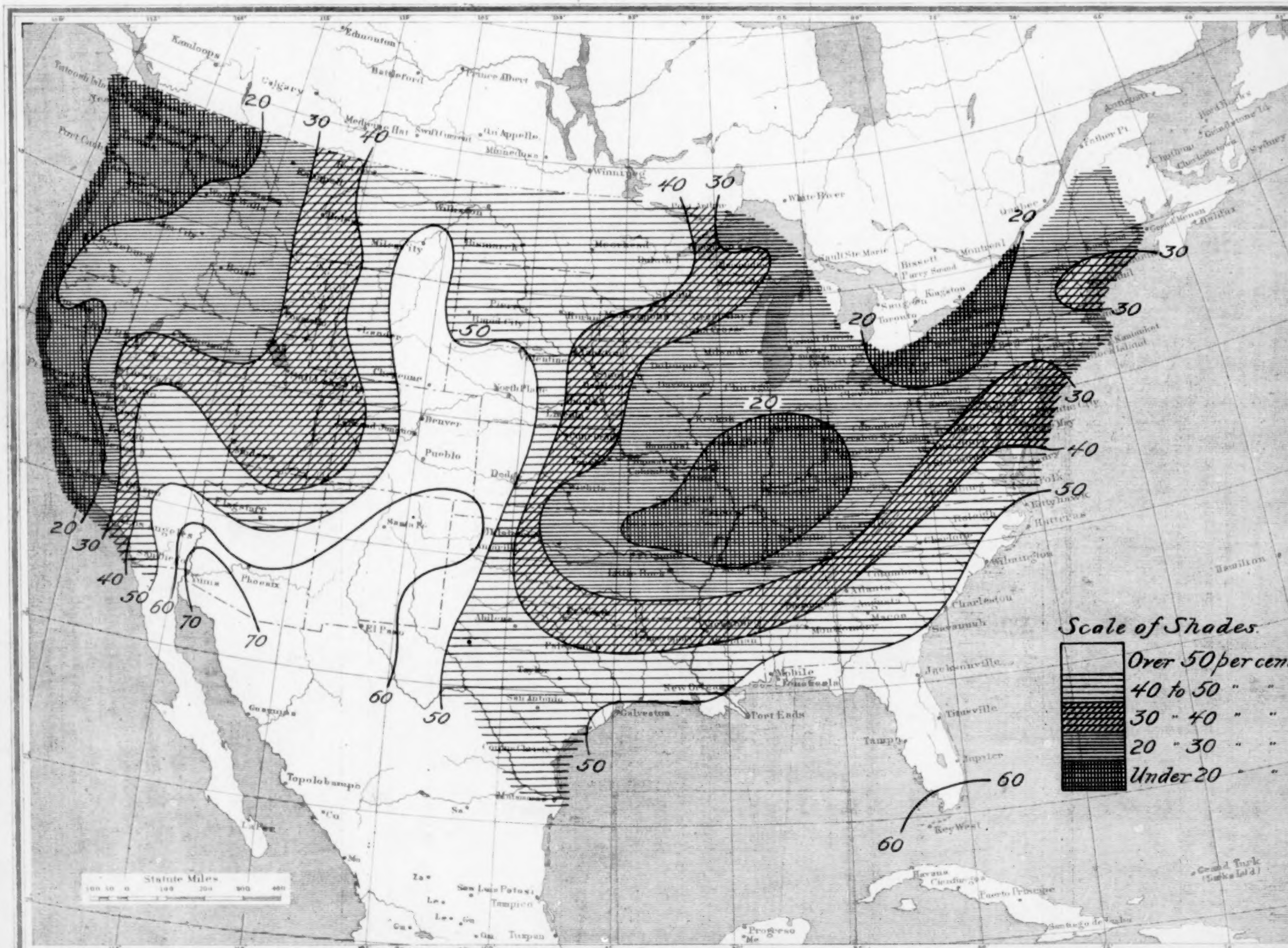
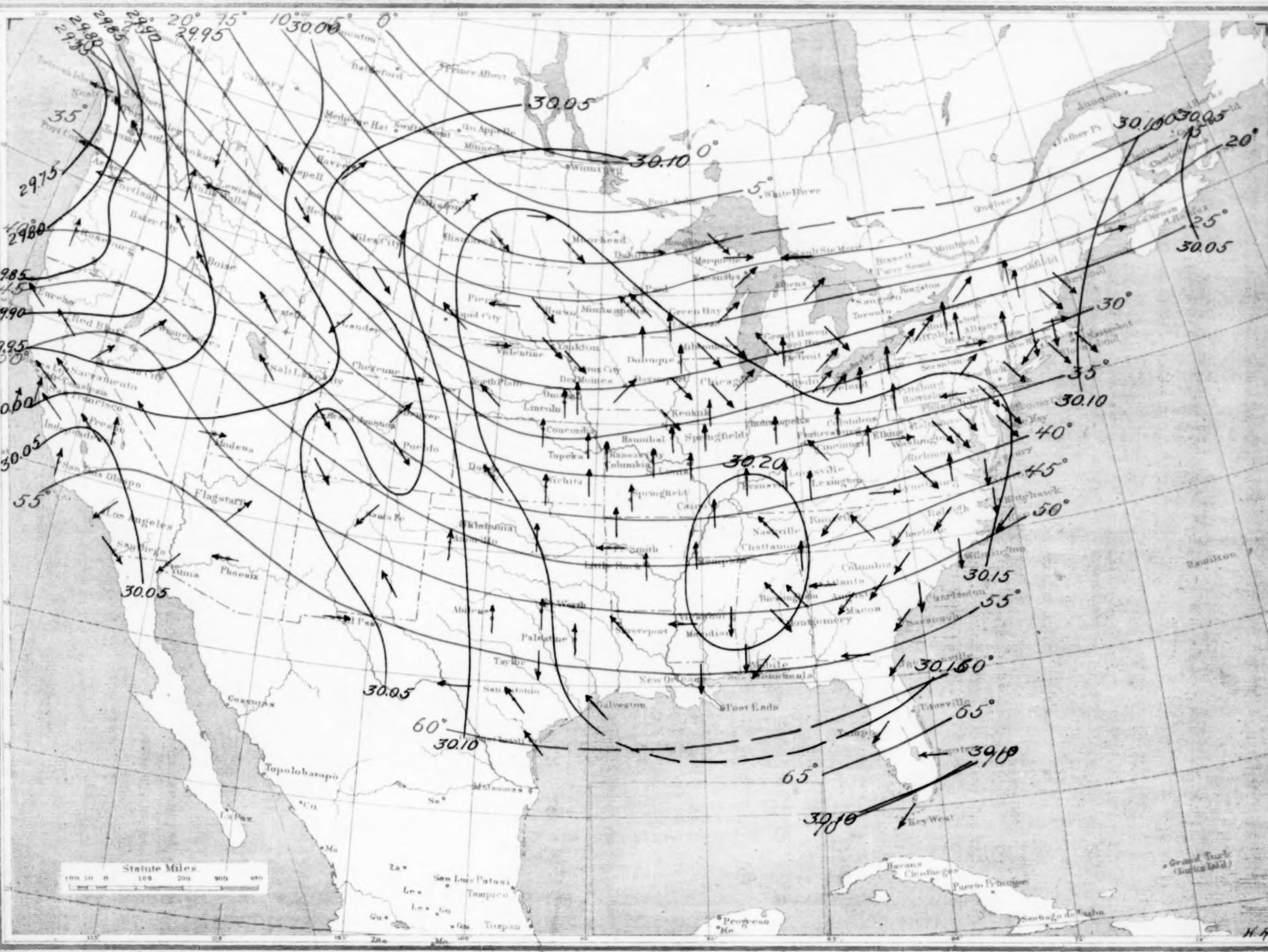


Chart VI. Isobars and Isotherms at Sea Level; Prevailing Winds, January, 1909.



 • Barkerville

Chart VII. Total Snowfall for January, 1909.

Chart VII. Total Snowfall for January, 1909.

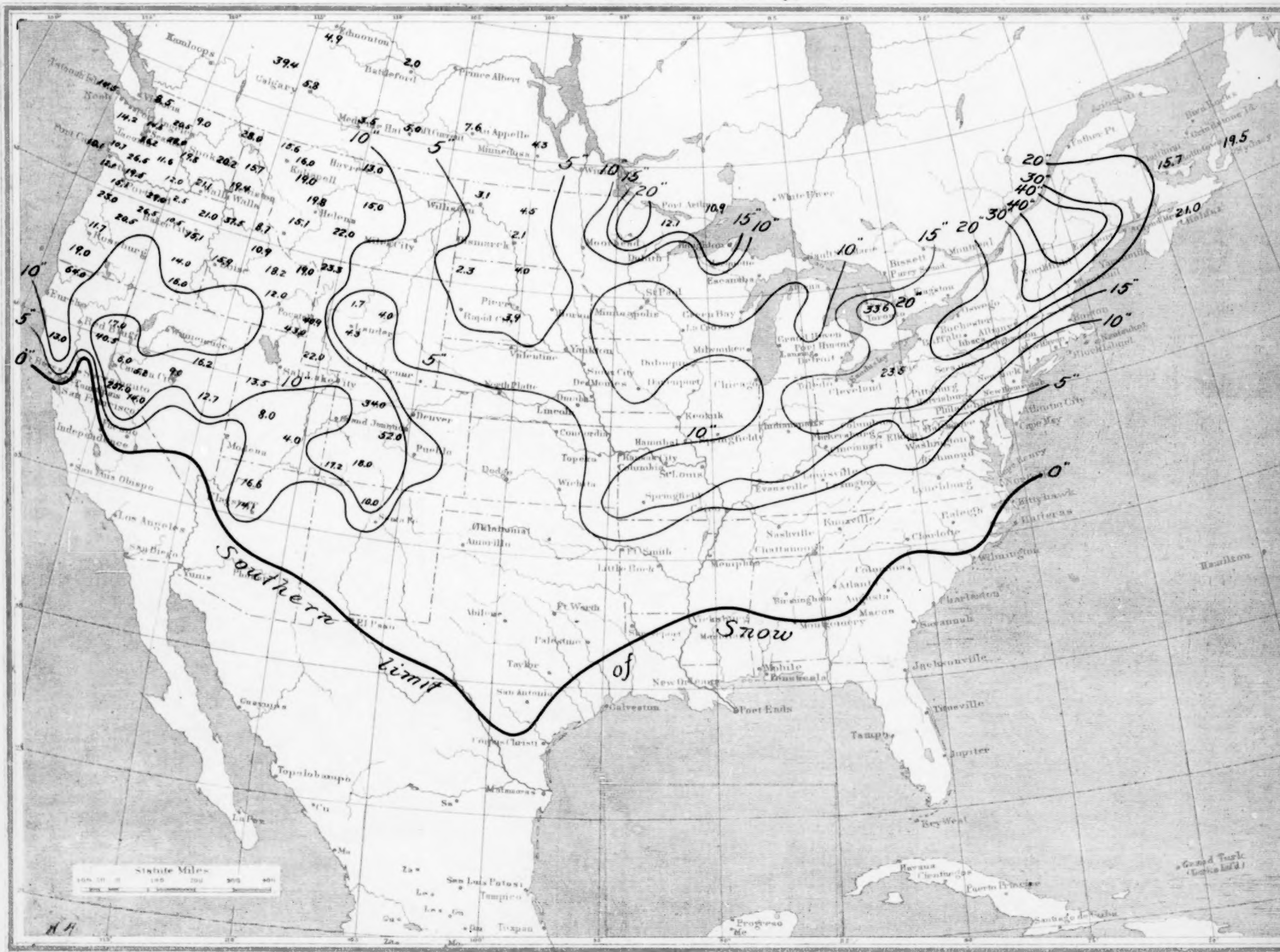


Chart VIII. Depth of Snow on Ground, January 31, 1909.

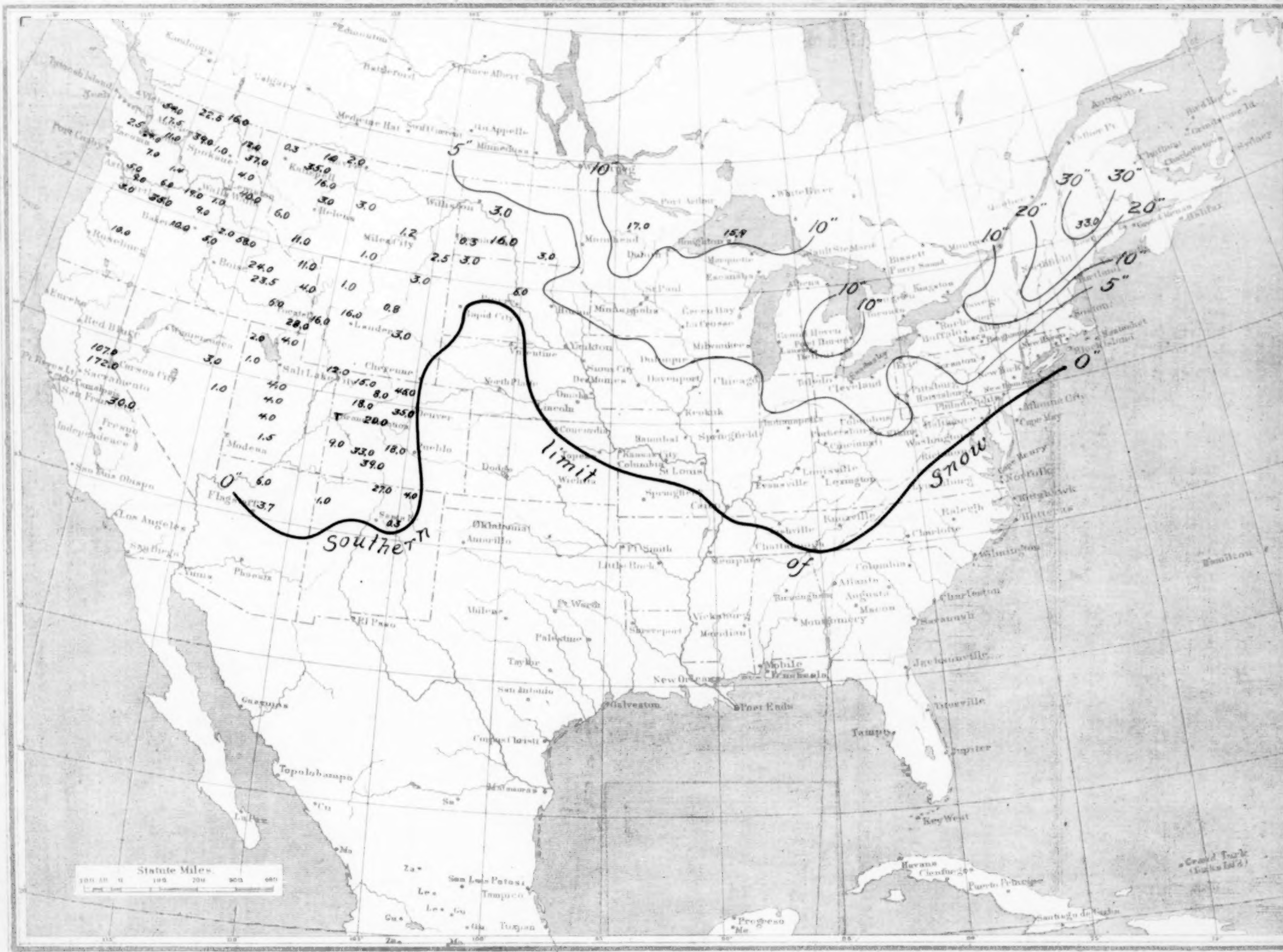


Chart IX.—Tracks of Canadian Low Areas, January, 1908.

Chart IX.—Tracks of Canadian Low Areas, January, 1908.

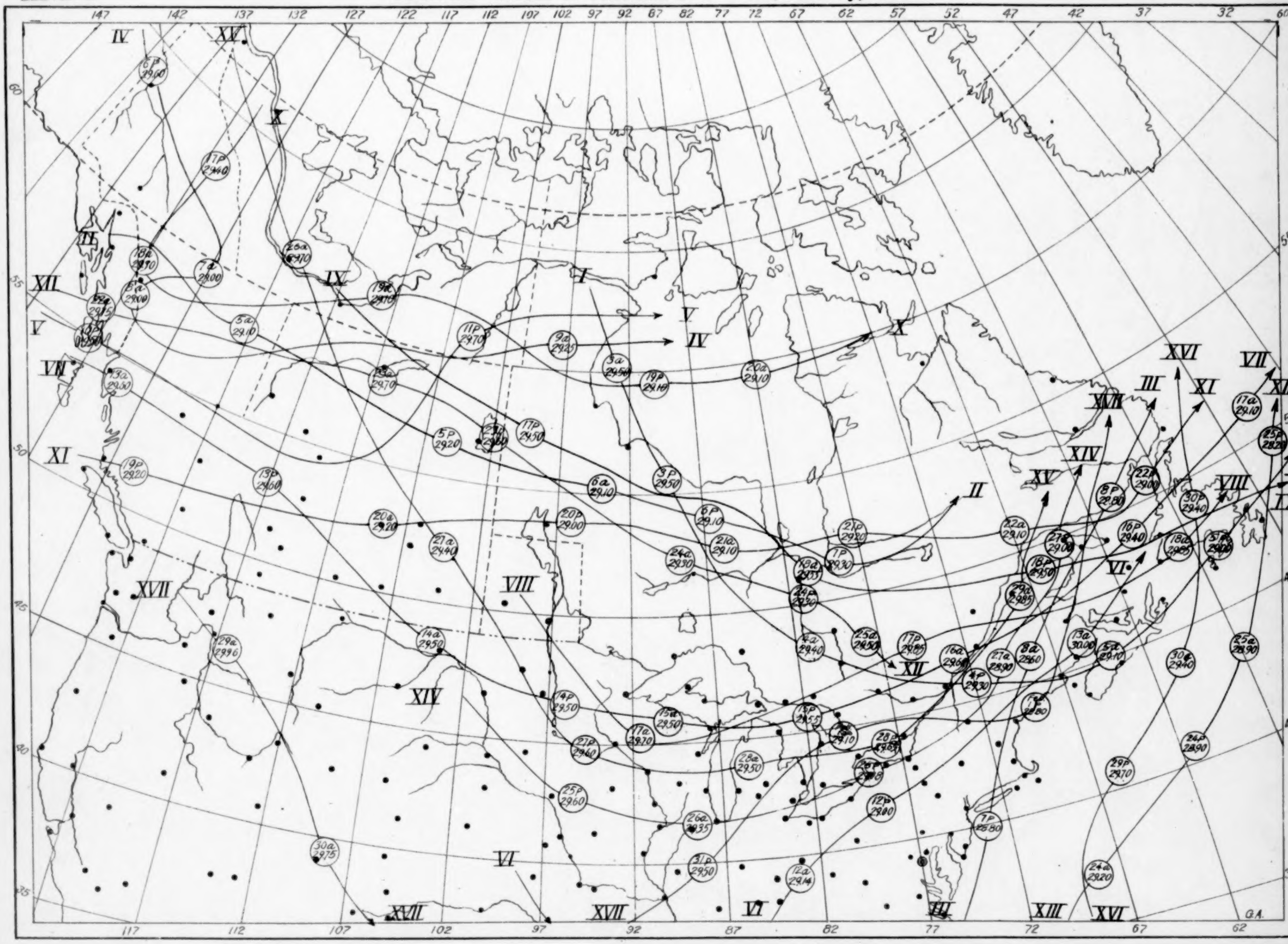


Chart X.—Isobars at Sea Level over Canada, January 27, 1908, 8 a. m.

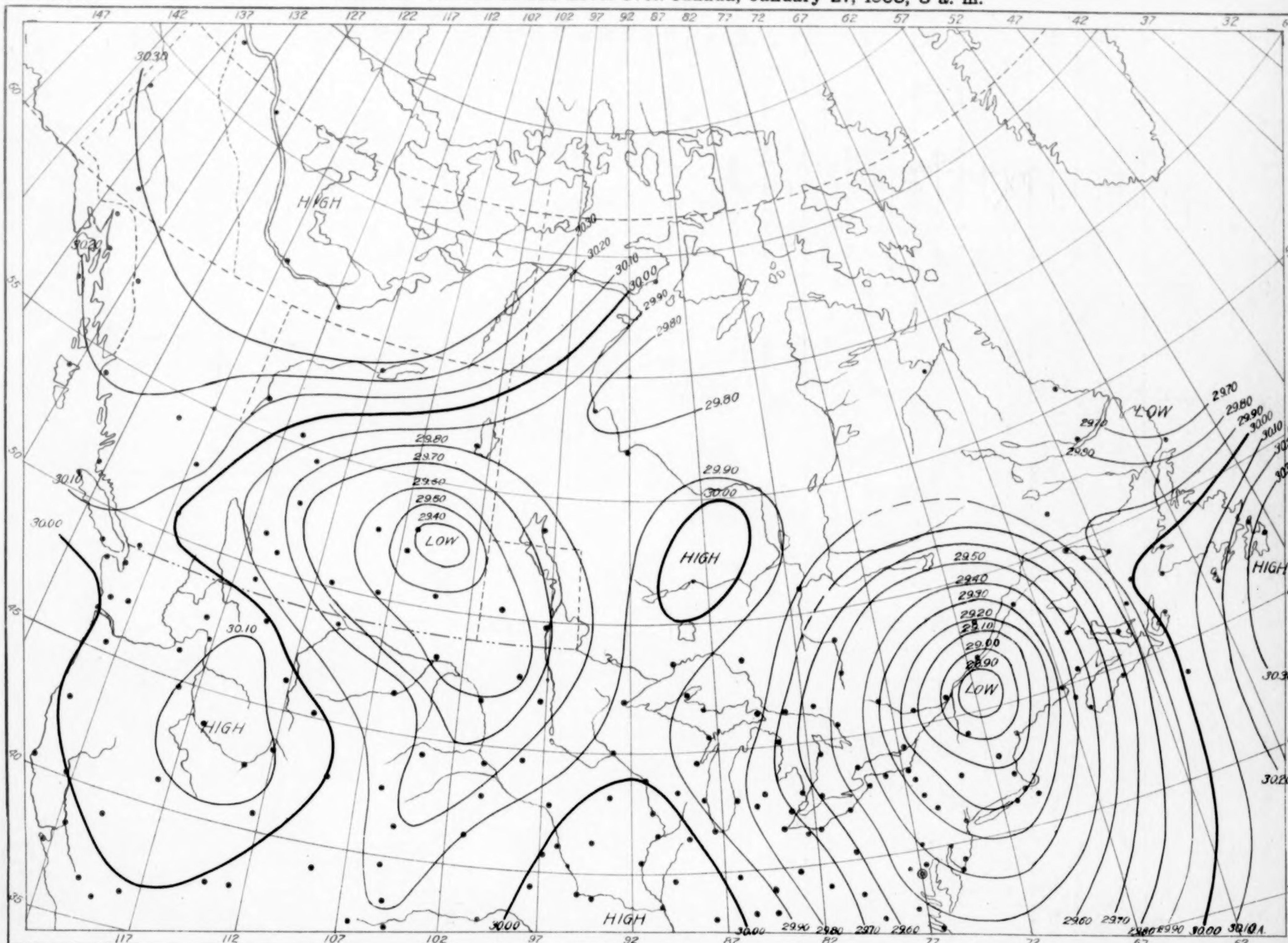


Chart XI. Marvin's Comparison of Vapor Pressures.

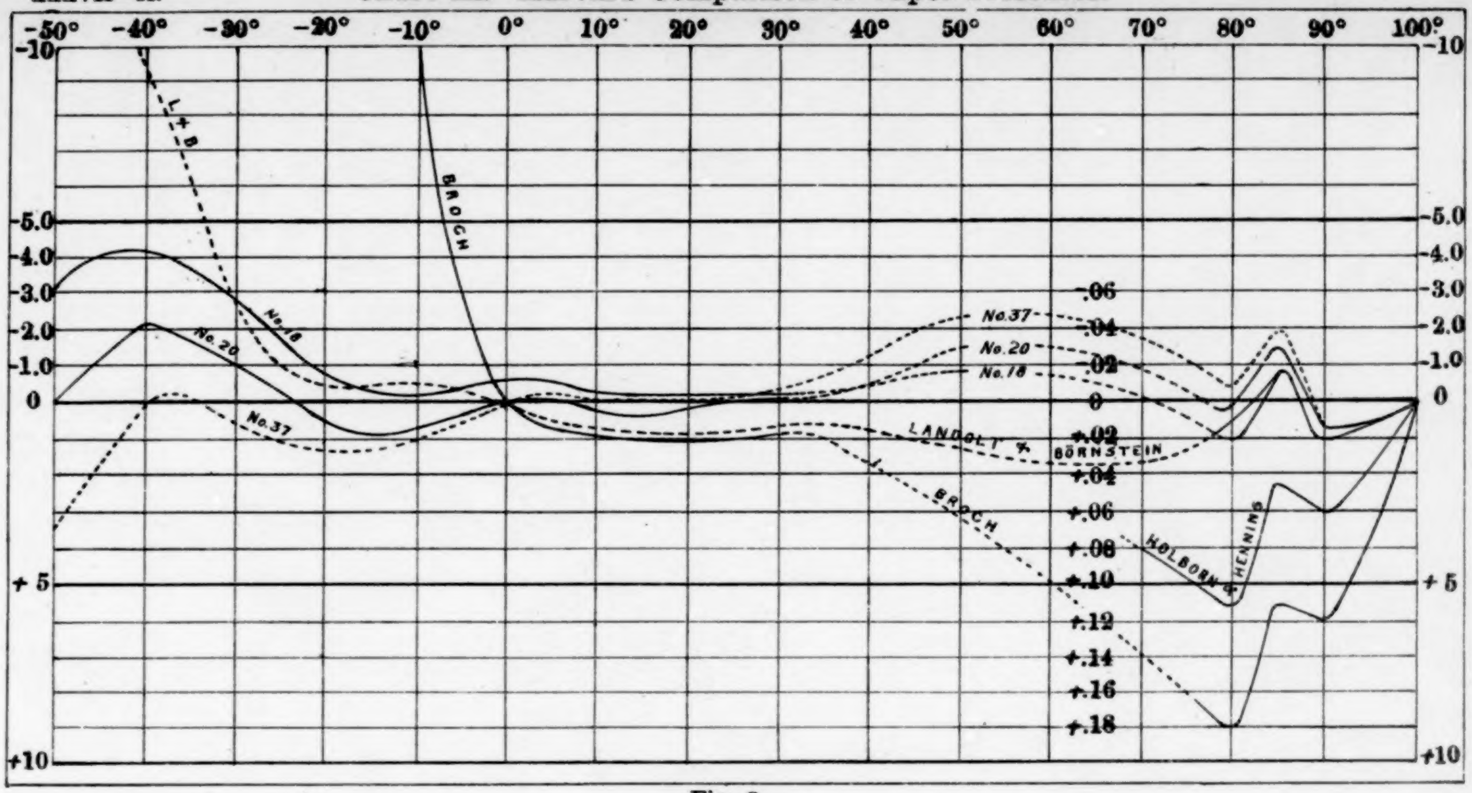
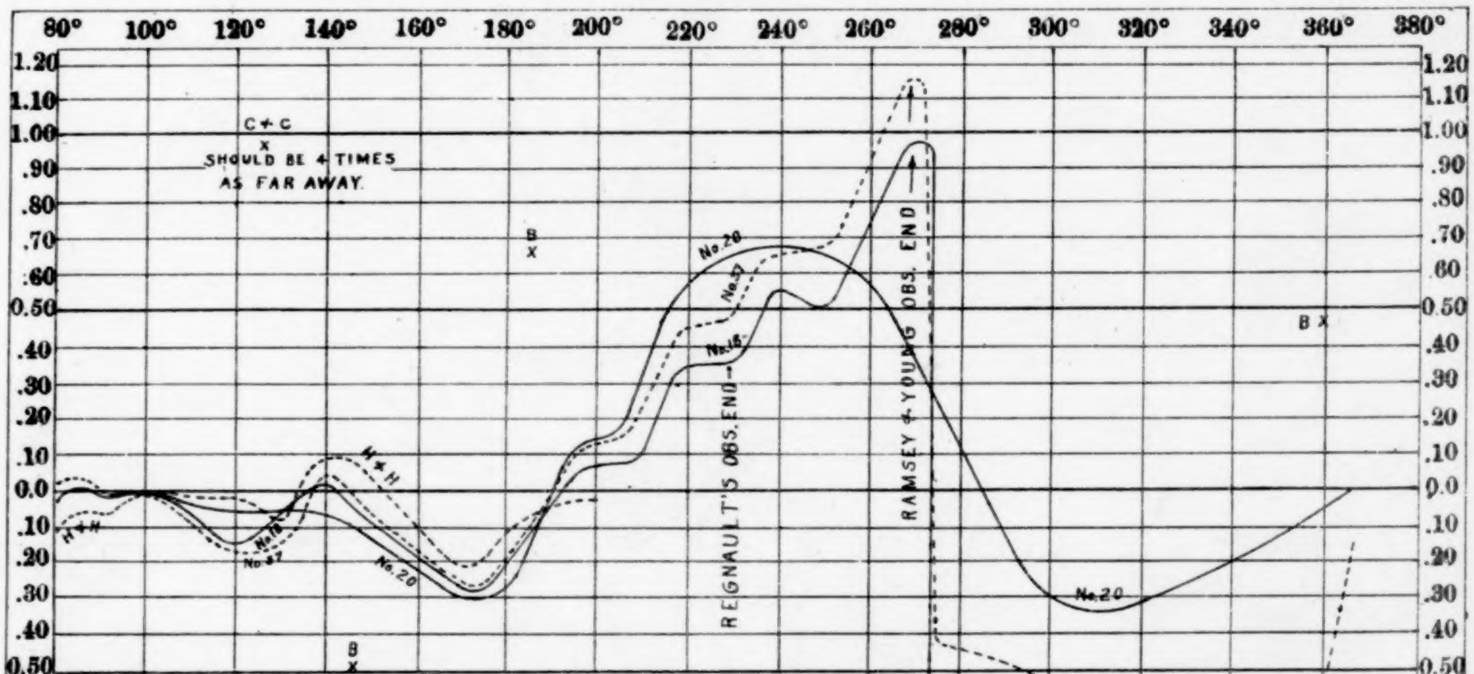


Fig. 2

Figs. 2 and 3.—Percentage departures of vapor pressures by different equations, from Ekholm's accepted observations.



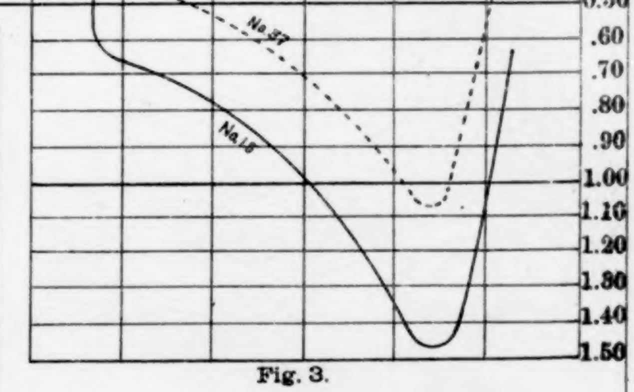


Fig. 3.

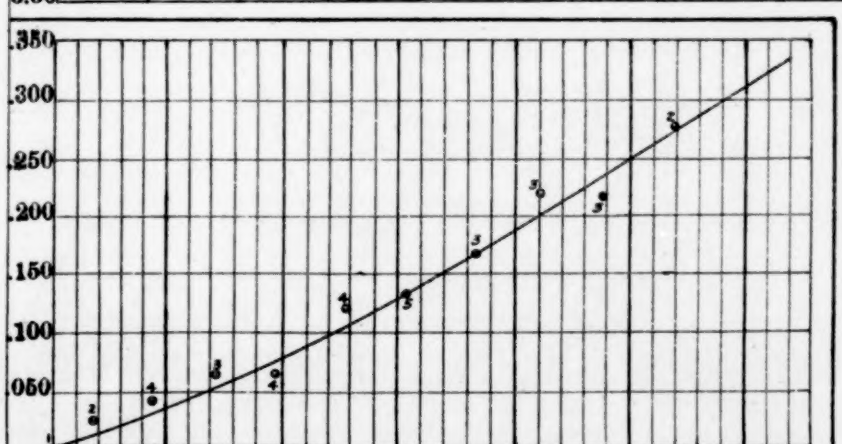


Fig. 1.—Difference in vapor pressures, (Marvin—Broch).

H. A.